MODEL 2449
WAVE & SPECTRUM ANALYZER

Quan-Tech®
Div. of KMS Industries, Inc.

Specialists in Electronic Instrumentation

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MODEL 2449
WAVE & SPECTRUM ANALYZER

Instruction Manual

MODEL NO.
SERIAL NO.
OWNER
PURCHASE ORDER NO.

This manual is furnished under the contract for the supply of the QUAN-TECH instrument listed above and contains instructions for the operation and calibration of the instrument for its intended use. The information contained in this manual shall not be either referred outside the owner's facility or used, duplicated, or disclosed in whole or in part for manufacturer or procurement without the written permission of QUAN-TECH, Div. of KMS Industries.

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Printed in U.S.A.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY

Quan-Tech Division KMS Industries, Inc. warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Electronic tubes and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misadjustments, misuse, or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

Calibration checks of this instrument can easily be made in accordance with the instruction manual. Routine readjustments **should never** be attempted. If, however, the instrument has been damaged and requires recalibration or alignment, explicit calibration procedures as defined in the instruction manual **must** be followed.

If any fault develops, the following steps should be taken:

1. Notify us, giving full details of the difficulty, and include the model number and serial number. On receipt of this information, we will give you service data or shipping instructions.

2. On receipt of shipping instructions, forward the instrument prepaid, to the factory. If requested an estimate of the charges will be made before the work begins provided the instrument is not covered by the warranty.

SHIPPING

The instruments should be packed in their original containers, or in a strong exterior container and surrounded by two inches of shock absorbing material.

Quan-Tech
Division of KMS INDUSTRIES, INC.

43 SOUTH JEFFERSON ROAD WHIPPANY, NEW JERSEY 07981

201-887-5508

CAUTIONS

1. PROPER GROUNDING of the electrical power must be provided. Failure to follow this warning may result in electrical shock to operating and maintenance personnel. Always exercise extreme care when working with the instrument out of its case. Refer to Section 4, Paragraph 4-1 for additional instructions.

2. OBSERVE proper power line voltage. Unless otherwise specified the unit is supplied from the factory to operate with 115 volt power. This can be verified by the power indicated on the serial number plate at the rear of the chassis. Consult Section 1, paragraph 1-5a for converting the instrument for 230 volt operation.

3. ADJUSTABLE CONTROLS not covered in the calibration instructions of Section 4 should NOT be disturbed. These controls are set at the factory during initial calibration and will not require further adjustment.

4. Proper SWEEP operation using the 7 Hz bandwidth filter is only obtained over a 5 KHz range and 500 second time period.

REGISTRATION OF THIS INSTRUMENT

The Model 2449 and this manual can be registered with QUAN-TECH by returning the tear-out postage paid mailer reply card located at the rear of this manual. This procedure will insure that the proper person will receive all manual revisions and future application notes pertaining to this instrument.

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INSTRUMENT REGISTRATION CARD AT REAR OF MANUAL

1-4c. Overall dimensions of the instrument for bench operation including handles, feet and panel components is: 8" height x 16 1/2" width x 12" depth.

1-4d. For inspection or servicing the 2449 chassis is removed from the front of the cabinet after removing four screws from the recessed panel at the rear of the cabinet.

1-4e. The Model 2449 may be rack mounted using adapters supplied with the instrument when the rack mounting option is specified. When rack mounting the instrument it is recommended that the carry handles, feet and bail be removed from the cabinet.

1-4f. Overall dimensions for the instrument mounted in a rack, with handles, feet and bail removed, will be:
7" height x 19" width x 11" depth behind rack panel
1" Protrusion in front of rack panel

1-5. ELECTRICAL POWER CHARACTERISTICS

1-5a. Unless otherwise specified the instrument is supplied from the factory for 115 Volt operation. The frequency of the power source may be 50 Hz to 1000 Hz. To set the instrument for 230 Volt operation remove the serial number plate at the rear of the unit and set the switch located behind the plate to the 230 position. Replace the serial number plate with the side showing proper voltage setting.

1-5b. Use only the three conductor power cord provided with the instrument, or an equivalent. If a grounding outlet is not available, an adapter must be used which provides a good grounding connection.

1-5c. The power requirements are approximately 12 volt-amperes. The unit is fused at the rear with a 1/4 ampere, Bussman Type MDC.

1-5d. The Model 2449 can be used for either line operation or battery operation when provided with an optional inverter mounted to the rear panel of the cabinet.

1-6. OPTIONS INCLUDED WITH THE EQUIPMENT

1-6a. A number of options are available for extending the features available in the Model 2449. When options are specified in the purchase of the equipment the instrument will be so marked at the rear of the chassis. Technical information relating to the included options will only be found in Section 6 of this manual.

1-7. PERFORMANCE SPECIFICATIONS

1-7a. The detailed performance specifications for the Model 2449 are presented in Table 1-1.

TABLE 1-1. PERFORMANCE SPECIFICATIONS OF MODEL 2449 WAVE AND SPECTRUM ANALYZER

FREQUENCY
- **Range:** 10 Hz to 50 KHz
- **Accuracy:** ±0.01%
- **Readout:** 5 digit electronic segment display
- **Resolution:** 1 Hz

INPUT SIGNAL
- **Voltage Range:** 30 μV to 300 V full scale in 15 ranges
- **Accuracy:** 5% of full scale
- **Dynamic Range:** Better than 75 decibels (dB)
- **Impedance:** 1 Megohm shunted with approx. 20 pico Farad (pF)

SELECTIVITY
- **Bandwidths:** 7, 100, 1000 Hz
- **Response:** Maximally flat, 24dB/octave (4 pole)

METER TIME CONSTANT (TC)
- **Time Constant:** 0.1, 1.0 and 10 seconds (sec)

SWEEP
- **Range:** 5 KHz and 50 KHz

INTERNAL CALIBRATOR
- **Accuracy:** ±2%
- **Frequency:** 10 KHz

AUTOMATIC FREQUENCY CONTROL (AFC)
- **Lock-in Range:** ±1 Bandwidth
- **Hold-in Range:** ±15 Bandwidths

OUTPUTS
- **Sweep Analog:** 0 to +5 V for any sweep range
- **Meter Analog:** 0 to +1 V proportional to meter deflection
- **BFO:** Sine wave at tuned frequency. Variable to 1 V into 600 ohms
- **Restored:** Replica of input signal after filtering by the selected bandpass variable to one volt into 600 ohms. (BFO and Restored are available simultaneously).

POWER INPUT
- **Voltage:** 103-127 volts/207-253 volts 50 −1000 Hz

Section 2

Operation

2-1. SCOPE OF THIS SECTION

2-1a. The material covered in this section will provide the user with sufficient instructions for the proper operation of the instrument. However, it is recommended that the user first review the technical material covered in Section 3, Principles of Operation. A thorough understanding of the design techniques used in the Model 2449 will greatly enhance its usefulness and possibly introduce new applications.

2-1b. Figure 2-1 located at the end of Table 2-1 illustrates the front panel controls, indicators and connectors.

2-2. DESCRIPTION OF CONTROLS, INDICATORS AND CONNECTORS

2-2a. The operating controls, indicators and connectors located on the front panel of the Model 2449 are described in Table 2-1.

2-2b. The operating controls and connectors on the rear panel of the Model 2449 are described in Table 2-2.

2-3. PREPARATION FOR USE AFTER SHIPMENT

2-3a. Inspect the instrument for signs of physical damage. If damage is evident refer to Claim for Damage in Shipment instructions in the front of this manual. This instrument requires a 3-prong power connection providing a good ground connection. DO NOT operate this instrument without proper grounding. Refer to AC Power Cautions in Section 4.

2-3b. Check the power line voltage specified for the instrument. Refer to the Serial number plate at the rear of the instrument for the voltage and frequency for which the instrument is wired.
NOTE: *To change the line voltage operation refer to the Maintenance Section of this manual.*

2-4. START-UP PROCEDURE

2-4a. Connect the instrument to the specified power line using the power cord supplied with the instrument.

2-4b. Turn instrument power on using the toggle switch on the front panel and allow at least 10 minutes for the instrument to stabilize before making any adjustments. Power ON condition is indicated by numerals appearing in the 5 digit light emitting diode (LED) display.

2-4c. Zero the meter as follows:

Set the frequency such that the instrument is tuned neither to an incoming signal nor the zero frequency carrier.

Turn the MILLIVOLTS switch counterclockwise to progressively more sensitive ranges. As the sensitivity of the instrument is increased, a residual voltage may be discernable. Alternately adjust the METER ZERO controls for a minimum meter reading, adjusting for the best possible null on the most sensitive range. (This should be less than 2% of full scale).

2-4d. The instrument is now ready for operation. However, for best performance, the above procedure should be repeated periodically.

2-5. INTERNAL CALIBRATION CHECK

2-5a. This check verifies correct operation of the Model 2449 signal circuits.

2-5b. Disconnect signal from INPUT connector.

2-5c. Adjust frequency control for 10,000 Hz on the LED display (FREQUENCY IN Hz).

2-5d. Set MILLIVOLTS FULL SCALE switch to CAL position.

2-5e. Correct operation is verified by a full scale meter reading (1.0 ±2%).

(Continued on Page 2-4)

TABLE 2-1. FUNCTIONAL DESCRIPTION OF THE CONTROLS, INDICATORS AND CONNECTORS ON THE FRONT PANEL (FIGURE 2-1)

POWER toggle switch (S1)	Applies AC line power to the instrument. Power "on" condition is indicated by numerals appearing in the 5 digit light emitting diode (LED) display.
INPUT (BNC) connector (J103)	The analog signal to be processed is applied to this connector. The impedance presented at this point is 1.0 Megohm shunted by approximately 20 Pico Farads. Signals up to 300 volts can be processed.
R.M.S. MILLIVOLTS meter (M101)	The panel meter is an average reading type calibrated in RMS using a sine-wave signal waveform.
Meter adjustment	The screwdriver adjustment located under the meter is a mechanical zero calibration for the meter pointer. Use this adjustment to set the pointer to "0" when the instrument power is off.
METER ZERO adjustments (R162, R163)	The two screwdriver adjustments provide a means of electronically balancing critically matched circuits which are subject to change with time and temperature. Circuit unbalance is indicated by a finite meter reading with power on and no signal applied to the INPUT connector. Use both adjustments to obtain minimum meter scale reading.
METER MULTIPLIER rotary switch (S104)	Ten (10) position step attenuator switch scales the input signal voltage to establish optimum levels for signal processing. Scaling is selectable in approximately 10 dB steps from X .01 to X 300. These multiplying factors are used in conjunction with the MILLIVOLTS FULL SCALE switch to scale the range of the meter.
VAR control (R118)	Inner shaft of METER MULTIPLIER switch providing linear potentiometer gain control (Variable) for operator selectable calibration, especially useful when using the DB meter scale. Detent position on maximum clockwise position labeled ABSOLUTE is the calibrated condition for reading the meter scale in conjunction with the METER MULTIPLIER and MILLIVOLTS FULL SCALE selection.
MILLIVOLTS FULL SCALE rotary switch (S105)	Seven (7) position step attenuator scales the meter full scale reading from 3 to 1000 millivolts. CAL position checks meter reading to "1" plus or minus 0.02, when the instrument is manually tuned to 10,000 Hz on the LED display.
OVERLOAD lamp (LED101)	Red indicating lamp when lighted shows excessive signal amplitude in the processing channel. Rotate METER MULTIPLIER switch clockwise to position that eliminates overload condition.
METER TC SEC rotary switch (S106)	Three (3) position rotary switch used to select meter time constants of 0.1, 1 and 10 seconds. These times represent the integration periods used to filter unstable or random signals processed by the Model 2449.
BANDWIDTH HZ rotary switch (S107)	Three (3) position rotary switch providing frequency selectivity by the choice of three bandwidths; 7, 100 and 1000 Hz.
FREQUENCY IN HZ readout	Five (5) digit LED display of the frequency to which the analyzer is tuned.
MANUAL frequency tuning controls (R110, R111)	The large rotary control and the FINE control each change the frequency of the voltage controlled oscillator (VCO) thereby tuning the instrument. The controls differ in both range and resolution, but are alike in that each control precisely converts angular motion to a change in frequency of the VCO.

SWEEP control	Two concentric rotary switches controlling the range and time of the electronic sweep.
RANGE, HZ rotary switch (S103)	Four (4) position inner shaft rotary switch allowing the selection of a 50K (Hz) sweep range or a 5K (Hz) sweep range.
	AFC position provides automatic frequency control operation when the analyzer is initally tuned to a signal that may vary in frequency.
	OFF position selects the manual mode of tuning the analyzer.
TIME, SEC rotary switch (S102)	Two (2) position rotary switch selects either 50 or 500 second period for the sweep excursion.
SINGLE/RESET toggle switch (S101)	Functional switch used in conjunction with the RANGE, HZ switch when placed in the 5K, 50K or AFC positions.
BFO (BNC) connector (J105)	Output connector providing a sinewave of the same frequency to which the analyzer is tuned.
BFO control (R151)	Linear potentiometer providing gain (attenuation) control, for scaling the output BFO signal.
RESTORED (BNC) connector (J106)	Output connector providing the input signal after filtering by the selected bandwidth.
RESTORED control (R152)	Linear potentiometer providing gain (attenuation) control for scaling the output RESTORED signal.
METER ANALOG (BNC) connector (J104)	Output connector providing the analog of the meter signal. Signal voltage 0 to plus 1 volt proportional to meter deflection.
SWEEP Analog (BNC) connector (J102)	Output connector providing the analog of the analyzer sweep. Signal varies from 0 to plus 5 volts for the selected sweep range.

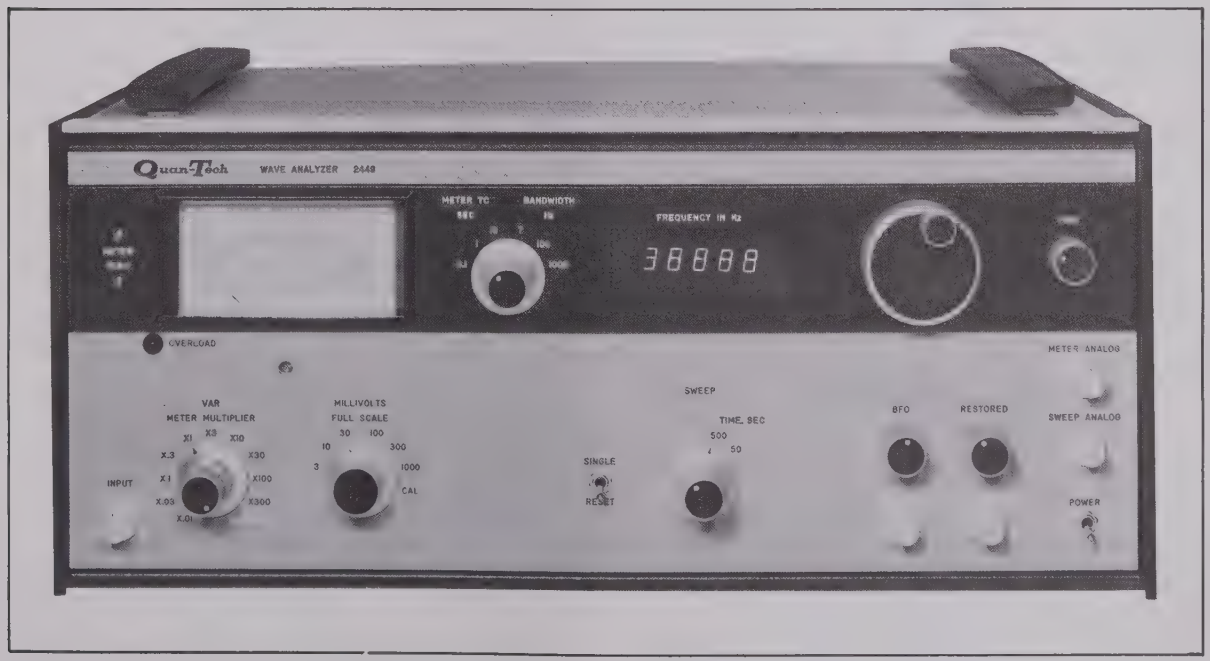


FIGURE 2-1. FRONT PANEL, MODEL 2449

TABLE 2-2. FUNCTIONAL DESCRIPTION OF THE CONTROLS AND CONNECTORS ON THE REAR PANEL

Line power connection (J1)	Three prong power connection, requires power cord, Cat. No. 1725B, Belden or equivalent.
Line power fuse (F1)	Fuse 1/4 ampere, Bussman Type MDC or equivalent.
115/230 volt switch (S1)	Power line selector switch located behind the Serial number plate.
CAL ADJ. control (R122)	Used in conjunction with other adjustments to set the internal calibration check.

2-6. MANUAL TUNING

2-6a. The actual procedure for operating the instrument depends on the nature of the test to be performed. A typical example of manual operation is as follows:

1. For harmonic distortion analysis process at 1 volt, 1 KHz signal from a test oscillator.
2. Set BANDWIDTH switch to 100 Hz.
3. Set MILLIVOLTS FULL SCALE switch to 1000.
4. Set METER MULTIPLIER switch to X1.
5. Turn the VAR (Variable gain) control clockwise to ABSOLUTE position (Detent position).
6. Select 0.1 on METER TC SEC switch.
7. Connect the signal to the INPUT (BNC) connector.
8. Tune frequency to 1000 on the FREQUENCY IN Hz display.
9. The meter should read full scale.

2-6b. Now that both the amplitude and frequency of the fundamental signal are known, measure the second harmonic content by tuning the frequency to twice the fundamental frequency (approximately 2 KHz). Rotate the MILLIVOLTS FULL SCALE switch counterclockwise until the meter reads up scale. This measure of the second harmonic may now be related to the fundamental signal by expressing its magnitude in percentage of, or decibels below one volt. Similarly, by successively tuning to 3, 4, and 5 KHz, the magnitude of the third, fourth and fifth harmonics of the fundamental may be measured.

2-7. AUTOMATIC FREQUENCY CONTROL (AFC)

2-7a. Adjust the instrument as in steps 1 thru 9 of Manual Tuning.

2-7b. Set the SINGLE/RESET switch to RESET position (effective AFC inhibit).

2-7c. Set SWEEP switch to AFC position.

2-7d. When SINGLE/RESET switch is switched to SINGLE the AFC becomes effective.

2-7e. Slowly vary the test signal ±1000 Hz.

2-7f. The FREQUENCY IN HZ display should follow the frequency.

2-7g. The AFC will hold for approximately ±15 times the BANDWIDTH switch setting.

2-8. AUTOMATIC ELECTRONIC SWEEP

2-8a. Select the RESET position on the SINGLE/RESET switch.

2-8b. Using the manual frequency adjust tune the instrument to the frequency at which the sweep is to start.

2-8c. Select the BANDWIDTH HZ position desired.

2-8d. Select the METER TC SEC position desired.

2-8e. On the SWEEP control select either the 5K or 50K position on the RANGE, HZ switch.

2-8f. On the TIME, SEC switch select the 50 or 500 position.

> NOTE: *When using a 7 Hz BANDWIDTH the 5K (Hz) and 500 (Sec) positions must be selected on the SWEEP control for proper signal processing.*

2-8g. Select the SINGLE position on the SINGLE/RESET switch to initiate the sweep.

2-8h. Instrument will make one frequency scan stopping at the top of the selected frequency range.

2-8i. Frequency will remain at top of range until manually varied or the RESET position is selected.

2-8j. A frequency spectrum may be plotted on an X-Y recorder by connecting the X axis to the SWEEP ANALOG (BNC) connector (0 to +5 VDC) and the Y axis to the METER ANALOG (BNC) connector (0 to +1 VDC). Activate recorder pen prior to step 2-8g.

Section 3

Principles of Operation

3-1. INTRODUCTION

3-1a. This section consists of two parts, the first being a general discussion of the design techniques used in the precision measurement of waveform frequencies. The technical discussion will be aided by following the block diagram of the instrument as illustrated in Figure 3-1. This diagram is located on the last page of this section and can be conveniently folded out for 100% viewing while reviewing the theory of operation.

3-1b. The second part of this section describes the circuits used in the electronic design of the Model 2449. The schematic diagrams used in the discussion are located in Section 5 of this manual and can be conveniently folded out for reference.

3-2. THEORY OF OPERATION

3-2a. The Model 2449 is basically a dual conversion hetrodyne receiver having a 100 KHz first Intermediate Frequency (IF) and a zero center frequency second IF.

3-2b. The variable oscillator is a voltage controlled oscillator (VCO) producing an output variable from 100 to 150 KHz. It is extremely stable and linear, and enables the instrument to be electronically swept over its whole range by an internal ramp in the SWEEP mode. In the AFC mode a phase detector controls the variable oscillator enabling the instrument to track a moving signal.

3-2c. Referring to the Block Diagram, the incoming signal goes through a step attenuator and amplifier into a low pass filter which removes frequencies above 50 KHz. The signal is buffered, then mixed with the output of the 100 to 150 KHz variable oscillator. The difference frequency is passed through the 100 KHz first IF to a pair of second modulators. The two second modulators are driven 90° out of phase by a two-phase 100 KHz crystal oscillator. The difference frequencies are then passed through a pair of four-pole maximally flat active low pass (LP) filters with selectable cutoff frequencies of 3.5, 50, and 500 Hz. Since the center frequency of the second IF is zero (DC), and the difference signals can go plus and minus, the resultant bandwidths are 7, 100 and 1000 Hz. The low frequency filtered signals from the two channels are then chopped at 100 KHz, again 90° out of phase, and recombined in a summing circuit. The summed signal is amplified and rectified, and drives the meter and meter analog circuitry.

3-2d. The BFO output is a constant amplitude signal of exactly the frequency to which the instrument is tuned. It is obtained by mixing the 100 KHz fixed oscillator with the 100 to 150 KHz variable oscillator and taking the difference frequency. Unwanted higher frequency modulation products are removed by a low pass filter.

3-2e. The RESTORED signal output is a filtered replica of the input signal exactly equal in frequency and proportional in amplitude. It is obtained by mixing the summed 100 KHz signal with the variable oscillator output and taking the difference frequency.

3-2f. In the AFC mode a phase detector compares the phase difference between the second (RØ, JØ) and fourth (Rn, Jn) poles of both of the low pass filters and produces a DC voltage of proper amplitude and polarity to tune the variable oscillator, so that the desired signal is in the center of the pass band. Control of the variable oscillator by the output of the phase detector is inhibited unless the signal is in excess of the tracking threshold. The output from the phase detector is attenuated in accordance with bandwidth.

3-3. CIRCUIT DESCRIPTION

3-3a. SWEEP GENERATOR & IMPEDANCE CONVERTER (FIGURE 5-2)

The Sweep Generator itself consists of Q1 and IC1, which form a Miller Integrator that charges C1 linearly with time. When the voltage across C1 reaches a value

equal to a reference voltage set by R6, IC2 prohibits further charging of C1. In the RESET mode C1 will remain discharged by Q2.

IC3 is an impedance converter which provides a variable reference voltage to IC4. IC4 also receives a differential reference voltage from the frequency control potentiometer on the front panel. IC4's output is used to drive the frequency analog and to control the frequency of the variable oscillator.

3-3b. VARIABLE OSCILLATOR AND DIVIDE BY 4 CIRCUIT (FIGURE 5-3)

The variable oscillator is basically an extremely stable, free-running multi-vibrator, Q1 and Q7. Its frequency is controlled from the impedance converter by linearly varying the current through Q2 and Q8. This current varies the discharge time of the timing capacitors C1 and C2. Q3 and Q6 function as non-linear collector loads to keep the dissipation in the circuitry at a minimum. Since multi-vibrators are often hard to start, there is a self-starting circuit consisting of Q4 and Q5. The output of the multi-vibrator is isolated and amplified by Q10 to provide maximum stability. The output of the oscillator is divided by 4 by IC1 to provide the 100 to 150 KHz variable oscillator output.

3-3c. BANDPASS FILTER, PREAMPLIFIER AND 1ST MODULATOR (FIGURE 5-4)

The input is a 1 megohm step attenuator using reed switches for control. Q1 is a low noise source follower which drives the variable gain amplifier IC1. A low pass filter rejects out of band frequency components which would result in spurious signals in the first modulator. The signal is buffered by IC2 and modulated by the Field Effect Transistor (FET) chopper Q5. As the instrument is tuned, the chopping frequency varies from 100 KHz to 150 KHz. A 100 KHz IF filter suppresses transients and harmonics of the modulator.

3-3d. STEP ATTENUATOR AND IF AMPLIFIER (FIGURE 5-5)

The output of the 100 KHz IF filter feeds amplifier IC1, which in turn feeds the MILLIVOLTS FULL SCALE step attenuator. The IF output amplifier Q1, Q2 and Q3, is driven directly from the step attenuator.

3-3e. LINE AC POWER, ±10 VOLT SUPPLIES, +5 VOLT SUPPLY (FIGURE 5-6)

The −10 Volt Supply has as its reference CR7. The error signal between this reference and the midpoint of the voltage divider formed by R7 and R10 is amplified by IC1, which drives the pass transistor Q3. The +10 Volt Supply is identical except for polarity. The +5 Volt Supply is similar except its reference is obtained from a divider, R5 and R6, from the +10 volt supply.

3-3f. METER CIRCUIT (FIGURE 5-7)

IC2 is a simple buffer to drive the meter and the METER ANALOG output. A threshold detector (IC1) is used to gate the AFC control in the presence of a signal.

3-3g. SUMMING AMPLIFIER AND DETECTOR (FIGURE 5-8)

The quadrature chopped signals from the Low Pass Filter Amplifier and Chopper are summed and filtered by the amplifier consisting of Q1, Q2, Q3 and their associated filter networks. This results in a 100 KHz carrier proportional to the input signal with a bandwidth as selected by the BANDWIDTH, HZ switch. Q7, Q8 and Q9 perform the same function except the signal to be summed is derived from the output of the second pole of the four pole low pass filters. The first summing network is called the N (Normal) channel and the second the Ø (Phase) channel. If the signal is detuned there will be a phase difference between these signals.

A phase detector consisting of squaring amplifiers IC2 and IC3 and a comparator IC4 controls the VCO in the AFC mode to follow an input signal. Q12 is a gate to inhibit AFC action. If the input signal level is below the threshold the normal channel signal is amplified by IC1 to drive the RESTORED circuit and the synchronous detector Q4.

3-3h. L.P. FILTER CAPACITOR (FIGURE 5-9)

The capacitors determining the active Low Pass Filter bandwidths are switched into the filter by a series of FET switches as selected by the BANDWIDTH, HZ switch.

3-3i. LOW PASS FILTERS AND AMPLIFIERS (FIGURE 5-10)

The R and J Channel filters and amplifiers are identical. Each of the filters consists of two two-pole active networks with capacitors selectable by the BANDWIDTH switch. The first section has a gain of approximately 50. The second section has a gain of slightly more than 1. The gains of the two amplifier sections are adjusted so that the overall response is that of a Butterworth filter. Separate outputs are taken from both the second (Ø) and the fourth (N) poles of each filter. The phase difference between these points is later measured in the phase detector and used to control the variable oscillator in the AFC mode. The gain in these channels is pre-set at the factory and should not be changed. Q1, Q2, Q3 and Q4 are the choppers for the Ø and N channels.

3-3j. FIXED OSCILLATOR AND 2ND MODULATOR (FIGURE 5-11)

The 100 KHz fixed oscillator frequency is derived from a 400 KHz crystal oscillator. The 100 KHz output is divided by four by IC2. The circuitry is so arranged as to obtain two 100 KHz outputs precisely 90° out of phase. The 100 KHz quadrature signals are used to drive the second modulators, Q3 and Q6 through Q4 and Q7. The outputs of the modulators are fed to the two low pass filters. The choppers are also driven from Q4 and Q7.

3-3k. TIME BASE (FIGURE 5-12)

The 100 KHz Fixed oscillator is used to generate an accurate 250 millisecond (ms) time base for the frequency readout. IC1, IC2, IC3, IC4 and IC5 provide the countdown circuit. IC6 and IC7 generate the latch transfer and counter reset pulses. IC6D inhibits the counter input during the latch transfer.

IC11 decoder strobes the LED readout anodes and the tri-state latches (Counter and Multiplexer board).

If the total count during the 250 ms period is less than 100 KHz (indicating the VCO is tuned below the fixed oscillator, i.e., negative tuning) IC12 will blank the 1st and 2nd most significant digits (MSD).

3-3l. COUNTER AND MULTIPLEXER (FIGURE 5-13)

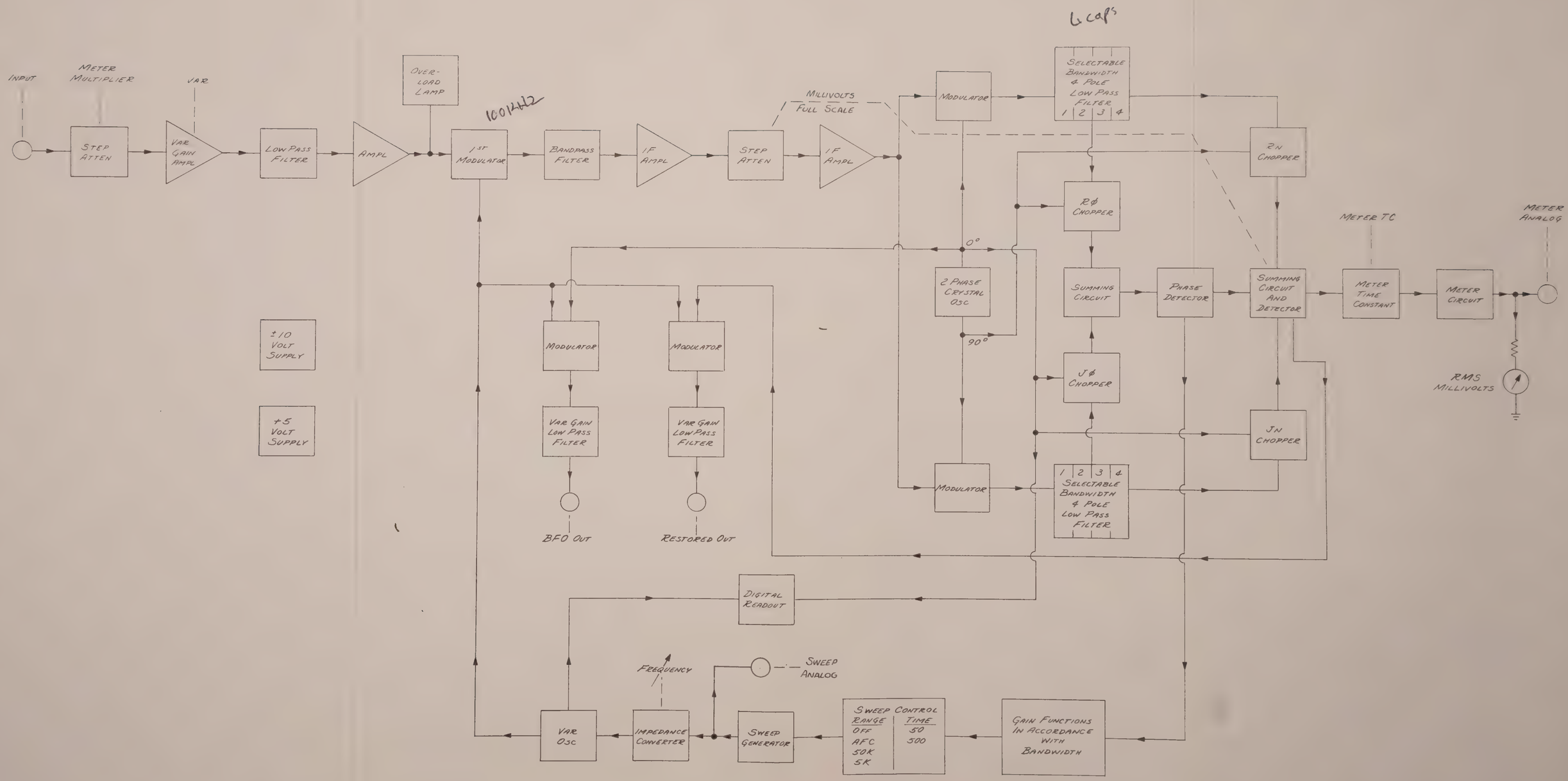
The 400 KHz to 600 KHz VCO signal is clocked into a 5 decade Binary Coded Decimal (BCD) counter. Four times per second the count is transferred to the latches. These latches are strobed by the TIME-BASE generator and drive the BCD to 7 segment decoder on the Readout board. The over-under count drives the blanking circuit on the TIME-BASE generator.

3-3m. BFO AND RESTORED (FIGURE 5-14)

The output of the VCO, through Q1, switches modulators Q2 and Q3, of the fixed oscillator and the N carrier signals to provide BFO and RESTORED outputs respectively. The difference frequency of each modulator is fed through an active low pass filter (4 pole), the output level is adjusted by a variable attenuator placed between the two sections.

3-3n. READOUT (FIGURE 5-15)

The light emitting diode (LED) readout is strobed at 1 KHz by the amode drivers, Q1 thru Q5. The drivers receive their signal from the Time Base (Figures 5-12). The decoder driver IC1 decodes the BCD data obtained from the Counter and Multiplexer (Figure 5-13). IC1 drives the 7 segments of each LED display.



D-8420-A

FIGURE 3-1. BLOCK DIAGRAM, MODEL 2449

Section 4

Maintenance

4-1. AC POWER CAUTIONS

4-1a. OBSERVE proper power line voltage. Unless otherwise specified the unit is supplied from the factory to operate with 115 volt power. This can be verified by the power indicated on the Serial number plate at the rear of the chassis. Consult Section 1, Paragraph 1-5a for converting the instrument for 230 volt operation.

4-1b. This equipment is supplied with a detachable, rubber-covered electrical ac power line cord. One termination of the cord is a standard three-contact female connector for mating the AC INPUT receptable on the instrument's rear panel. The other termination is a 3-prong male connector for mating a power source outlet, with one of the power source terminals at ground potential. THIS EQUIPMENT SHOULD NEVER BE OPERATED UNLESS IT IS PROPERLY GROUNDED.

4-1c. If you use a 2-prong to 3-prong adapter for mating to your power source outlet, make sure that the pigtail lead (the grounding strap which is provided on the 2-prong adapter) is securely grounded. FAILURE TO FOLLOW THIS WARNING MAY RESULT IN ELECTRICAL SHOCK TO OPERATING AND MAINTENANCE PERSONNEL.

4-1d. Nominal 115-volt or 230-volt ac potentials are present on the terminals of the front panel power switch and on the rear panel ac power input connector and line protective fuse. ALWAYS EXERCISE EXTREME CARE WHEN WORKING IN OR NEAR THESE AREAS TO AVOID SEVERE ELECTRICAL SHOCK!

4-2. MAINTENANCE INSTRUCTIONS

4-2a. All printed circuit boards are stamped with a four digit number, the last two digits indicating the "Board Number" as referred to in Sections 3, 4 and 5 and in Table 4-1.

4-2b. Table 4-2 list the test equipment required to perform maintenance on the Model 2449.

TABLE 4-1. IDENTIFICATION OF PLUG-IN BOARDS

BOARD NO.	FUNCTION	FIGURE NO.
01	Sweep Generator and Impedance Converter	5-2
02	Variable Oscillator	5-3
03	Pre-Amplifier and 1st Modulator	5-4
04	IF Amplifier	5-5
05	Power Supply	5-6
06	Meter Circuit	5-7
07	Summing Amplifier and Detector	5-8
10	LP Filter Capacitor	5-9
11	LP Filter Amplifier	5-10
12	Fixed Oscillator 2nd Modulator	5-11
13	Time Base	5-12
14	Counter and Multiplexer	5-13
15	BFO and Restored	5-14
16	Extender	—

4-2c. Table 4-3 lists the performance checks to verify that the Model 2449 is operating within specifications. The performance checks may be used for incoming inspection, periodic maintenance and as a verification of calibration after a repair. Use these performance checks to verify the analyzer performance before attempting internal adjustments or making repairs.

4-3. CALIBRATION INSTRUCTIONS

4-3a. The Model 2449 is a precision instrument, the accuracy of which depends, in large part, on critically balanced DC circuitry. The circuits in turn are designed to operate over a moderate temperature range. However, the instrument cannot cope with thermal shocks or transients which cause differential temperatures to occur between individual components. The closed-box environ-

Section 4

Maintenance

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4-1d. Nominal 115-volt or 230-volt ac potentials are present on the terminals of the front panel power switch and on the rear panel ac power input connector and line protective fuse. ALWAYS EXERCISE EXTREME CARE WHEN WORKING IN OR NEAR THESE AREAS TO AVOID SEVERE ELECTRICAL SHOCK!

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ment provided by the Model 2449's case affords its circuits both thermal-transient and electrostatic shielding, thereby resulting in more stable operation. During calibration similar protection may be required in the interest of accuracy. It is also recommended that the "extender board" supplied with each instrument be used in the case of those adjustments which cannot be made without removing the circuit board. If a circuit board must be temporarily removed from its socket, or if the unit is momentarily turned off, be sure to allow the instrument time to restabilize before making further adjustments.

4-3b. Following is an outline of the setup procedure. It is important that the adjustments be made in the prescribed order, inasmuch as some of them depend upon completion of the previous ones.

4-3c. Adjustment Procedure Outline:

a. Frequency Determinants
   (1) Power Supplies
   (2) Variable Oscillator and Impedance Converter
   (3) Fixed Oscillator
   (4) Sweep Circuits
b. Signal Channel
   (1) Meter Zero Adjustments
   (2) R/J Channel Balance
   (3) Calibrate Gain Circuit
   (4) Check Systems Gain

4-3d. The instrumentation recommended for use in calibrating the Model 2449 is described in Table 4-4.

4-3e. The Model 2449 can be properly calibrated by following the procedure outlined in Table 4-5.

CAUTION

Included in this procedure are a number of adjustments which require the actual selection and installation of components. These particular adjustments are intended to be made ONLY on new assemblies or those which have received catastrophic damage, necessitating a major overhaul. An asterisk indicates factory selected components on the schematics.

Those adjustable controls not covered in the "Calibration Procedure" should NOT be adjusted. These are set at the factory during initial calibration and will not require further adjustment.

TABLE 4-2. TEST EQUIPMENT REQUIRED FOR PERFORMANCE CHECKS OF MODEL 2449

NAME	CHARACTERISTICS	RECOMMENDED MODEL
OSCILLATOR	Output: Sine Wave Frequency Range: 10 Hz to 50 KHz	Hewlett-Packard 651B
AC VOLTMETER	Frequency Range: 10 Hz to 50 KHz Voltage Range: 1 mV to 3 Volts	Hewlett-Packard 400D
TERMINATION	BNC, 50 ohm, Feedthru Type	Tektronix 011-0049
TERMINATION	BNC, 600 ohm, Feedthru Type	Tektronix 011-0092
TEST CABLE	BNC Male to BNC Male	Pomona # BNC-C-36
TEST CABLE	BNC Male to Double Plug	Pomona 2 BC-BNC-36
DIGITAL VOLTMETER	Input Voltage Range: 0 to 5 Volts Accuracy: ±0.1% of Full Scale	Fairchild 7050

TABLE 4-3. PROCEDURE FOR CHECKING THE PERFORMANCE OF THE MODEL 2449

PRELIMINARY INSTRUCTIONS:
Connect the Model 2449 to a proper source of AC power and turn POWER switch on. Allow 15 minutes stabilization time before proceeding with tests.

Adjust the FREQUENCY control for a reading of 10,000 Hz on the Frequency Readout. Set the MILLIVOLTS FULL SCALE switch to 3.

Alternately adjust both METER ZERO controls for best possible null on the meter.

STEP	OPERATION OF TEST EQUIPMENT AND MODEL 2449	PERFORMANCE STANDARDS
	INPUT VOLTAGE CHECK	
1.	Connect the 50 ohm termination to the 50 ohm output of the test oscillator. Connect a test cable from the termination to the INPUT connector. Adjust the test oscillator for: Amplitude: 3.00 Volts rms Frequency: 10 KHz	
2.	Set the Model 2449 controls as follows: METER MULTIPLIER: X3 VAR: Maximum clockwise (ABSOLUTE) MILLIVOLTS FULL SCALE: 1000 FREQUENCY: 10,000 Hz BANDWIDTH: 1000 Hz METER TC: 0.1 Sec SWEEP: OFF	Meter should read 3.0 V ± 5%
3.	Set the Model 2449 controls as follows:	

	METER MULTIPLIER	MILLIVOLTS FULL SCALE	METER READING
a.	X10	300	3 mV ±5%
b.	X30	100	3 mV ±5%
c.	X100	30	3 mV ±5%
d.	X300	10	3 mV ±5%

4. Adjust the Test Oscillator for:
   Amplitude: 10 mV rms
   Frequency: 10 KHz

   Set the Model 2449 controls as follows:

	METER MULTIPLIER	MILLIVOLTS FULL SCALE	METER READING
a.	X.01	1000	10 mV ±5%
b.	X.03	300	10 mV ±5%
c.	X.1	100	10 mV ±5%
d.	X.3	30	10 mV ±5%
e.	X1	10	10 mV ±5%
f.	X3	3	10 mV ±5%

TABLE 4-3. (Continued)

STEP	OPERATION OF TEST EQUIPMENT AND MODEL 2449	PERFORMANCE STANDARDS
	FREQUENCY RESPONSE CHECK	
5.	Adjust the Test Oscillator for Amplitude: 1 Volt rms Frequency: 10 Hz Set the Model 2449 controls as follows: METER MULTIPLIER: X1 MILLIVOLTS FULL SCALE: 1000 BANDWIDTH: 7 Hz FREQUENCY: 10 Hz SWEEP: OFF Readjust the Test Oscillator, as required, to produce a full scale meter reading.	
6.	Set the frequency of the Test Oscillator at various points over the range of 10 Hz to 50 KHz. At each frequency point set the FREQUENCY control to produce maximum meter deflection.	At each frequency point the meter should indicate 1.0 ±5%
	SELECTIVITY CHECK	
7.	Adjust the Test Oscillator for: Amplitude: 1 Volt rms Frequency: 10 KHz Set the BANDWIDTH control to 1000 Hz and the FREQUENCY control for maximum meter deflection at 10000 Hz. Readjust the Test Oscillator, as required, to produce a full scale meter reading.	
8.	Adjust the FREQUENCY control (toward 10, 500 Hz) for a meter reading of 0.71. Record the frequency reading. Adjust the FREQUENCY control (toward 9, 500 Hz) for a meter reading of 0.71. Record the frequency reading. Subtract the second reading from the first.	The difference in frequency readings should be equal to 1000 Hz ±10%
9.	Set the Bandwidth Control to 100 Hz. Adjust the FREQUENCY control (toward 10, 050 Hz) for a meter reading of 0.71. Record the frequency reading. Adjust the FREQUENCY control (toward 9, 950 Hz) for a meter reading of 0.71. Record the frequency reading. Subtract the second reading from the first.	The difference in frequency readings should be 100 Hz ±10%
10.	Set the BANDWIDTH control to 7 Hz. Adjust the frequency control toward 10, 003 Hz for a meter reading of 0.71. Record the frequency reading. Adjust the FREQUENCY control toward 99997 Hz for a meter reading of 0.71. Record the frequency reading. Subtract the second reading from the first.	The difference in frequency readings should be 7 Hz ±2 Hz
	METER ANALOG OUTPUT CHECK	
11.	Connect a test cable from the test Digital Voltmeter to the METER ANALOG connector. Adjust the test oscillator for a full scale meter reading on the Model 2449.	The Test Digital Voltmeter should read 1.00 Volts ±2%
12.	Disconnect the Test Oscillator from the Model 2449 INPUT connector.	The Test Digital Voltmeter should read 0 V, ±10 mV

TABLE 4-3. (Continued)

STEP	OPERATION OF TEST EQUIPMENT AND MODEL 2449	PERFORMANCE STANDARDS
	SWEEP ANALOG OUTPUT CHECK	
13.	Connect the test cable from the Test Digital Voltmeter to the SWEEP ANALOG connector. Set the SWEEP switch to RESET, the RANGE switch to 50 KHz and TIME switch to 50 Sec.	The Test Digital Voltmeter should read 0 Volts ±10 mV
14.	Set the SWEEP switch to SINGLE.	The Test Digital Voltmeter should indicate a uniformly increasing voltage. At the end of 50 seconds, it should read +5 Volts ±2%
	BFO OUTPUT CHECK	
15.	Connect the 600 ohm Termination to the BFO output connector. Connect a test cable from the test AC Voltmeter to the termination. Turn the BFO level control maximum clockwise. Set the RANGE switch of the Test AC Voltmeter to 1 Volts.	The test AC voltmeter should read greater than 1.0 Volts
	RESTORED OUTPUT CHECK	
16.	Connect the test cable from the test oscillator to the Model 2449 INPUT connector. Connect the 600 ohm termination and test cable to the RESTORED output connector. Set the SWEEP switch to RESET. Adjust the test oscillator for a full scale meter reading on the Model 2449. Turn the RESTORED level maximum clockwise.	The Test AC Voltmeter should read greater than 1.0 Volts
	AFC CHECK	
17.	Set the Model 2449 controls as follows: BANDWIDTH: 1000 Hz SWEEP RANGE: AFC SWEEP: RESET FREQUENCY: 30,000 Hz Adjust the Test Oscillator for a frequency of 30 KHz.	
18.	Set the SWEEP switch to SINGLE. Slowly adjust the Test Oscillator frequency to 50 KHz.	The Frequency indicated on the FREQUENCY Readout should be greater than 45,000 Hz
19.	Slowly adjust the Test Oscillator frequency to 10 KHz.	The Frequency indicated on the FREQUENCY Readout should be less than 15,000 Hz.

TABLE 4-4. TEST EQUIPMENT REQUIRED FOR CALIBRATING THE MODEL 2449

a. VOM	Avometer or equivalent 20,000 Ohm/Volt
b. Digital Voltmeter	Fairchild 7050 or equivalent
c. Oscillator	10 Hz to 100 KHz, 1 Volt output
d. VTVM	HP 400D or equivalent
e. Oscilloscope	Tektronix 503 or equivalent
f. Oscilloscope	50 MHz response with low-capacitance probe
g. Frequency Counter	Range 500 KHz, accuracy 0.1%
h. Decade Attenuator	GR 1450 or equivalent

TABLE 4-5. PROCEDURE FOR CALIBRATING THE MODEL 2449

1. Initial Setting of Controls

METER ZERO Controls	Midrange
METER TC	0.1 SEC
MILLIVOLTS FULL SCALE	1000
BANDWIDTH	100 Hz
FINE Control	Midrange
Frequency Readout	00000
METER MULTIPLIER	X1
VAR (Control)	ABSOLUTE
SWEEP RANGE	50 KHz
SWEEP TIME	50 SEC
SWEEP FUNCTION	RESET

2. Calibration of Frequency Control Circuits

NOTE: *ALLOW INSTRUMENT TO WARM UP FOR 15 MINUTES BEFORE ATTEMPTING THE FOLLOWING PROCEDURES:*

a. POWER SUPPLIES Board 05; Test Equipment: Item b.
   (1) Monitor the minus 10 Volt Test Point (TP) with D.C. Voltmeter. Should read minus 10 Volts, ± 50 millivolts. If necessary, adjust R1 for correct reading.
   (2) Monitor the plus 10 Volt TP. Adjust R3 if necessary, for 10 Volts, ±50 mV.
   (3) Monitor the plus 5 Volts TP. 4.75 to 5.25 Volts is within range.

b. SWEEP GENERATOR Board 01; Test Equipment: Item b.
   Front panel controls as "Initial Setting".
   (1) Monitor Sweep Analog TP with Voltmeter. Adjust R2 for 0 Volts ±10 millivolts. Set SWEEP to SINGLE. At the end of the sweep period, 50 sec., adjust R6 to 5 Volts ±10 millivolts.

c. IMPEDANCE CONVERTER Board 01; Test Equipment: Item b.
   (1) Set SWEEP to RESET. Monitor FREQUENCY ANALOG TP with voltmeter. Set FINE Frequency tuning control to midrange and the COARSE tuning control for 0 Volts, at TP. Switch SWEEP to SINGLE, allow instrument to complete sweep, adjust FREQUENCY ANALOG +5 Volt Adj. (R22) to 5 volts ±10 mV.
   (2) Set SWEEP RANGE to 5 KHz. FREQUENCY ANALOG TP should be 0.5 volts ±25 mV.

TABLE 4-5. (Continued)

(3) Check SWEEP TIME 50 and 500 seconds. Set SWEEP to RESET, and, using a watch or clock measure the time for the SWEEP ANALOG or SWEEP TP to sweep from 0 to 5 volts when the SWEEP is set to SINGLE. Since this function is used in X-Y plotting of data the time is not critical, ±20% is adequate.

d. VARIABLE OSCILLATOR board 02; Test Equipment: Item b.
Front panel controls as in "Initial Setting"
(1) Adjust Variable Oscillator Ref. Adj. (+5 V), R22, using TP to +5.25 volts ±10 mV.
(2) Adjust Variable Oscillator OSC ZERO ADJ., R1, for 00000 Hz on the front panel display.
(3) Tune the coarse and FINE tuning controls for 5 volts at the FREQUENCY ANALOG TP on Board 01, then adjust the 50 KHz ADJ. R6 for 50000 Hz display on the front panel readout.

e. FIXED OSCILLATOR Board 12; Test Equipment: Item g
(1) No Frequency adjustment is required on the Fixed oscillator. If there is a question of its frequency, use a scope probe into the counter from the crystal (top terminal). The frequency should be 400 KHz ±0.01% at room temperature.

3. Calibration of the Signal Channel
Front panel controls as in "Initial Setting" except, tune the frequency readout to 10000 Hz and set MILLIVOLTS FULL SCALE switch to 3.

a. LOW PASS FILTER Board 11; Test Equipment: Item c.
(1) Adjust the front panel METER ZERO controls to mid range.
(2) Adjust the COARSE R (R19) and J ZERO (R1) for minimum meter deflection.
(3) Adjust front panel METER ZERO controls for accurate minimum deflection.
(4) Set MILLIVOLTS FULL SCALE Switch to 1000 and apply 1 volt 10 KHz sinewave to the input. Carefully tune either the generator or Model 2449 to within a few Hz of each other. Then adjust the R-J BAL. control (R17) for minimum meter ripple.

b. METER CIRCUIT Board 06; Test Equipment: Items b and c.
(1) With no signal at the input, tune to approximately 10 KHz (be sure the METER ZERO controls are carefully adjusted). Adjust TC BAL. (R7) for zero on the meter.
(2) Apply a 10 KHz signal and monitor the METER ANALOG TP. Adjust signal level for 1 volt output, then adjust METER CAL. (R11) for a reading of 1.0 on the meter.

c. SUMMING AMPLIFIER AND DETECTOR Board 07; Test Equipment; Items c, d, and e.
(1) With 1 volt 10 KHz applied to the input, adjust SYSTEM GAIN with R5 for a 1 volt meter reading. The rear panel CAL adj. should be at mid range.
(2) Using the X and Y inputs of a scope monitor the R out and J out TP's on Board 11, Low Pass Filter. A rotating circular pattern will be observed. Set SWEEP to AFC and SINGLE. Adjust Track Bal. adj. (R35) for minimum rotation. **NOTE:** *Often a phase lock on the signal is obtained but is not required for AFC operation.*
(3) Vary the input Frequency and the instrument should follow the signal over approximately ±15 bandwidths. In the 100 and 7 Hz bandwidths, the AFC action is slower, thus the input Frequency cannot be changed too rapidly.
(4) Decrease the signal level to approximately 10% of full scale; adjust the THRESHOLD ADJ. (R2) on Board 06 until the AFC lock is released.

d. CALIBRATE CIRCUIT
The internal calibrate signal is obtained from the BFO circuit.
(1) Set the MILLIVOLTS FULL SCALE switch to CAL. and the FREQUENCY to 10 KHz. Adjust R113 on the connector board for a Full Scale (1.0) meter reading. **NOTE:** *The instrument MUST be calibrated to make this adjustment.*

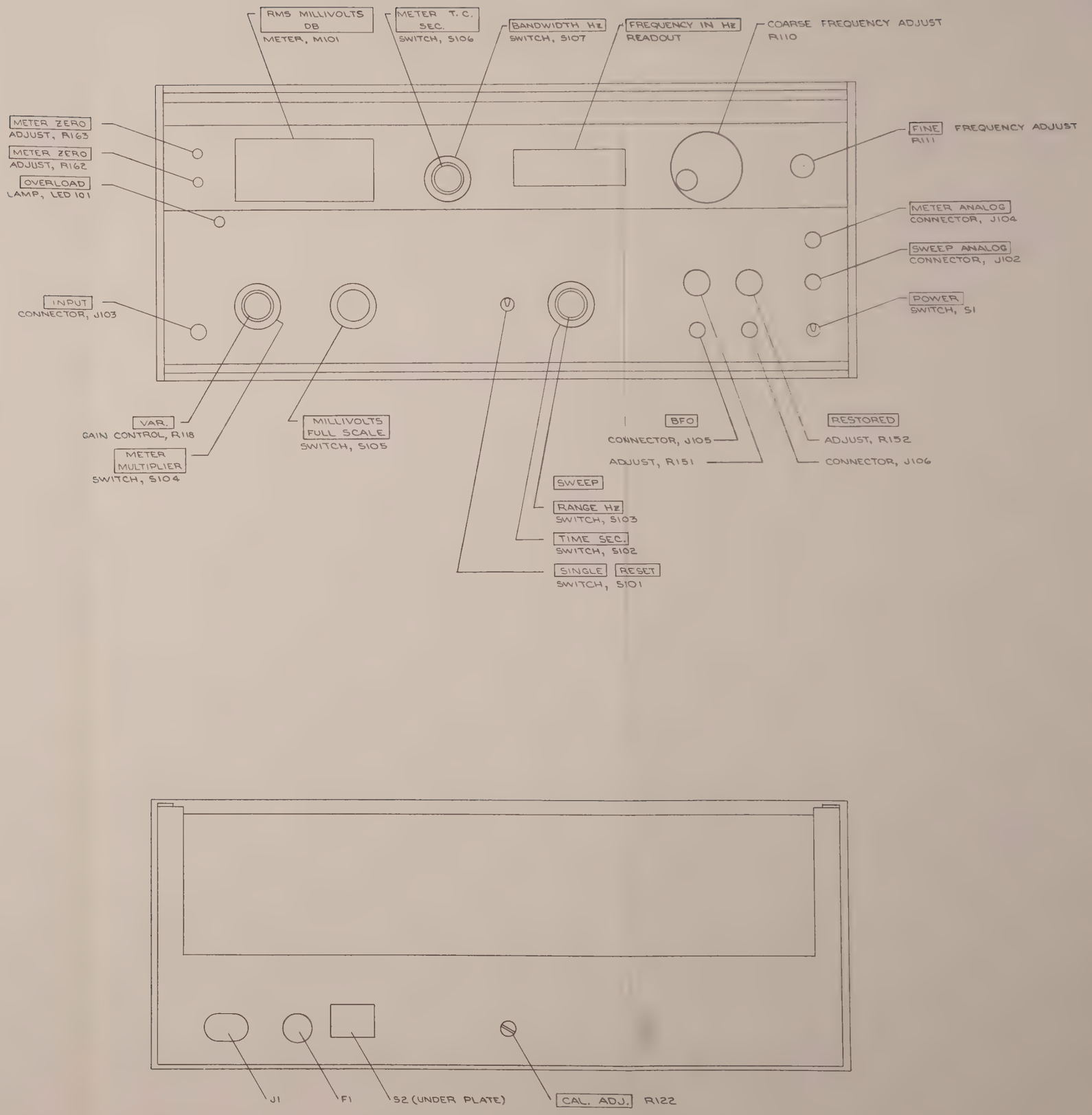


FIGURE 4-1. CONTROL, INDICATOR AND CONNECTOR LOCATIONS

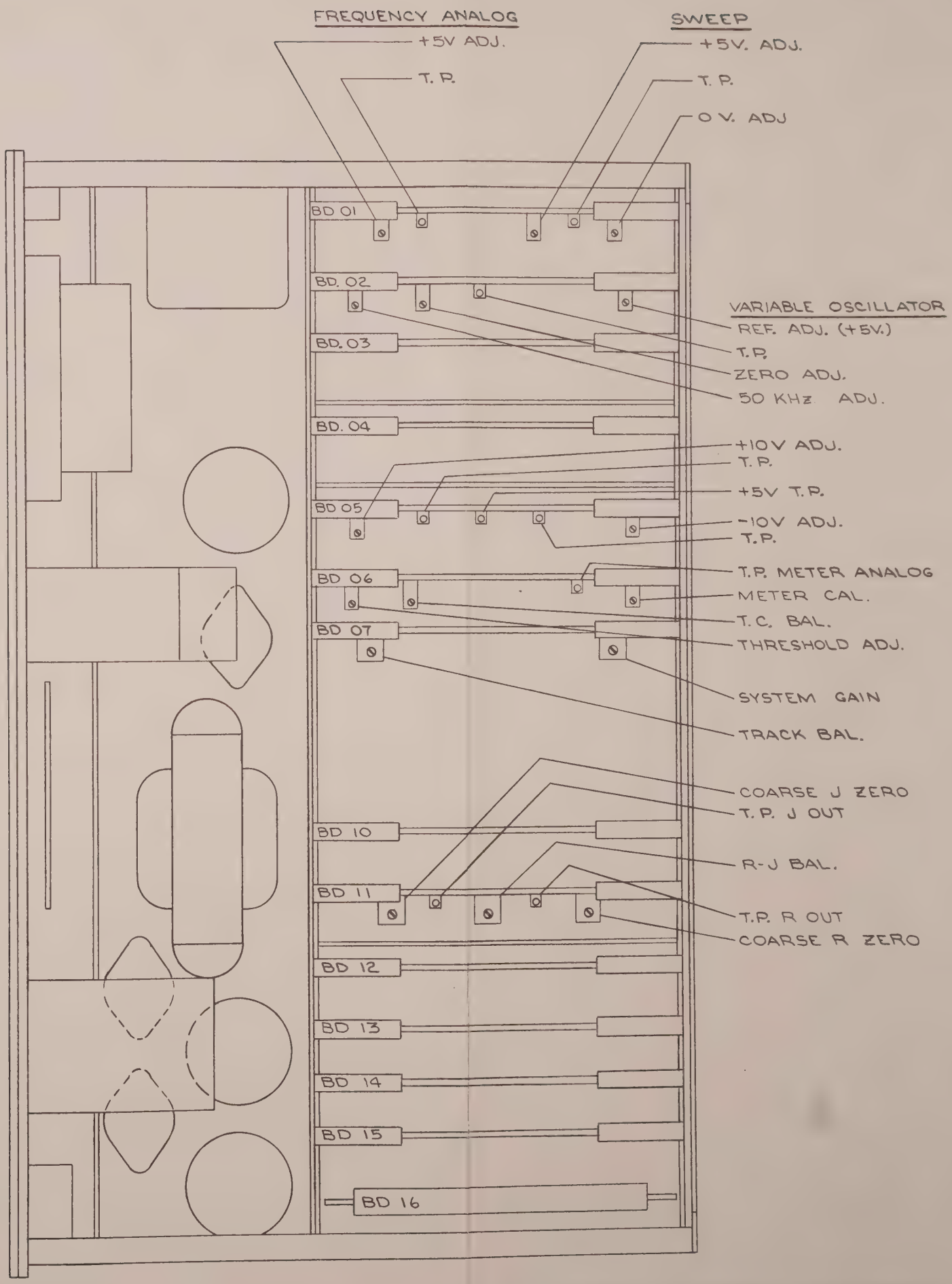


FIGURE 4-2. LOCATION OF INTERNAL ADJUSTMENTS

Section 5

Parts List and Circuit Diagrams

5-1. SCOPE OF THIS SECTION

5-1a. All the information normally required for trouble shooting and repairing the Model 2449 is included in this section. This data includes schematic drawings, component layout drawings and replaceable parts lists.

5-2. SCHEMATIC DRAWINGS

5-2a. Figures 5-2 thru 5-15 located on the following pages contain the schematic diagrams of each plug-in component board and its functional relationship to components located on the main frame (chassis). The schematic diagrams are included on fold out sheets for convenient reference with reviewing Sections 3 and 4 of this manual.

5-2b. Unless otherwise specified, all resistances and capacitance values shown on the schematics are:

Capacitance in "microfarads"
Resistance in "ohms"
All ±1% resistors have 1/8 watt ratings
All other resistors have 1/4 watt ratings

5-2c. The schematic drawings contain the following legends:

K	–	1000
Pf	–	Picofarads
*	–	Component selected at factory
⊘	–	Screw driver adjustment
SWEEP	–	Border indicates front panel control

5-3. COMPONENT LOCATIONS

5-3a. Component layout drawings are located to the left of each schematic drawing. Components not mounted on a printed circuit board can be located on the Connector Board or frame (Figure 5-1).

5-3b. The solid dot (●) indicated on IC components identifies the location of Pin 1.

5-4. REPLACEABLE PARTS LISTS

5-4a. Tables identifying the replaceable electronic components in each assembly are located to the left of the layout drawings. (Figures 5-1 thru 5-15)

5-5. SEMICONDUCTOR LEGEND

5-5a. Changes and improvements in the semiconductor products available for commercial use necessitates type changes from time to time. To eliminate confusion and costly paperwork, many of these changes will be covered in the following legend. The purpose of this legend is to acknowledge the fact that the type number on a semiconductor found in a piece of equipment will not necessarily correspond with the type number given on the schematic diagram.

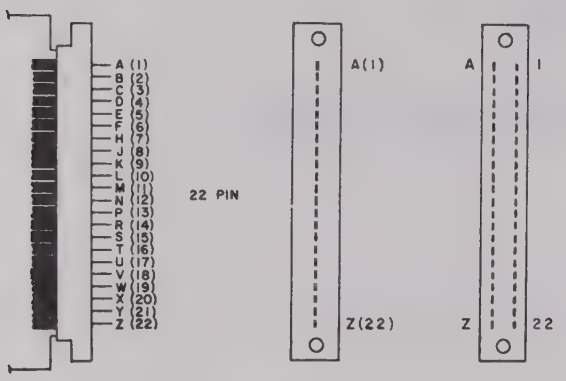
5-5b. The legend is not intended to be an interchangeability list although in many cases good quality components within a given category may be substituted with acceptable results. Normally, replacements should be made using components having the same type number as the component being replaced.

5-5c. Those components bearing an asterisk on the schematic diagram are factory selected components and should be obtained from Quan-Tech.

5-5d. It should be noted that the incoming inspection procedure followed at Quan-Tech includes noise screening on most semiconductors.

5-6. PRINTED CIRCUIT BOARD LUG IDENTIFICATION

5-6a. The identification and orientation of a printed circuit board and connector, utilizing 22 pins, is illustrated as follows:



When a printed circuit board of a lesser number of pins is called for, the same designating sequence shall apply.

5-6b. When a single sided copper P.C. Board is used, its pin identification shall be as shown, and its schematic references shall be A(1), B(2), C(3) etc. The copper side faces the observer when viewed as shown at the left.

5-6c. When using a double sided copper P.C. Board its pin orientation shall be as shown and its schematic references shall be as follows:

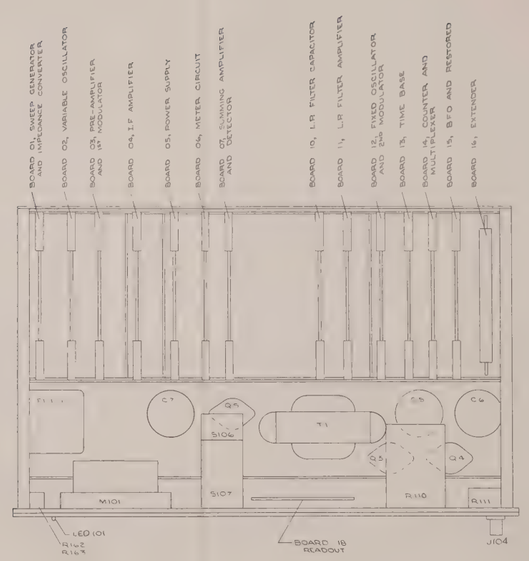
a. (A), (B), (C) etc. signifies that electrical connections are made to lettered side of P.C. Board (A side).
b. (1), (2), (3) etc. signifies that electrical connections are made to numbered side of P.C. Board (1 side).
c. A(1), B(2), C(3) etc. signifies that electrical connections are made to both sides of P.C. Board simultaneously, i.e., A and 1 are schematically connected.

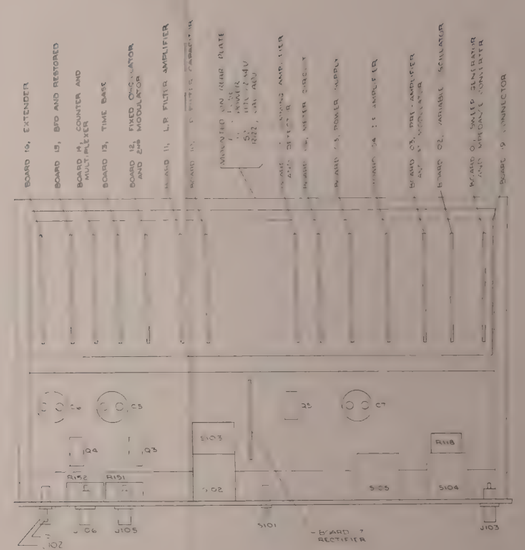
SEMICONDUCTOR LEGEND

TYPE NO. ON SCHEMATIC	TYPE NO. IN EQUIPMENT
1N482A	1N648, 1N3604, 1N3605
1N703	1N748, 1N749
1N709	1N753
1N2859	1N3253, 1N3254
1N2862	1N3254
1N3253	75A4, 1N3254
1N3254	75A4
1N3604	1N3605, 1N482A, 1N648
1N3605	1N3604, 1N482A, 1N648
TIS73	TIS75
TI480	2N1613, 2N3566, 2N3643 A322, 2N929
TI494	2N1613, 2N3566, 2N3643, A322, 2N929
UC240	2N4869, 2N3819
2N270	2N3644, 2N3250, 2N3251
2N396A	2N414, 4JX1G759, 4JX1D653, 2N3644, 2N3250, 2N3251
2N414	2N396A, 4JX1G759, 4JX1D653, 2N3644, 2N3250, 2N3251
2N929	A322, A324, A642, 220N2, 2N3566, 2N3643, 2N2219
2N1304	2N1306, 2N3566, 2N3643, A322
2N1306	2N1304, 2N3566, 2N3643, A322
2N1515	2N3644, 2N3250, 2N3251
2N1613	2N3566, 2N3643, A322, 2N2219
2N2219	D16C33, 220N2, A322, A324, A642, 2N3566, 2N3643
2N2603	2N3250, 2N3251
2N3250	2N3251, 2N3644
2N3251	2N3250, 2N3644
2N3566	2N3643, A322, 2N929, 2N2219
2N3643	2N3566, 2N2219, A322, 2N929
2N3644	2N3250, 2N3251
2N3819	TIS73, TIS75, TIS59, 2N4869, UC240,
2N4869	2N3819, UC240

TABLE 5-1. REPLACEABLE PARTS LIST

SYMBOL	PART NO.	DESCRIPTION
Main Frame and Panel Components		
C5,C6		Capacitor, 2700 mfd, 25V, Sprague Type 36D
C7		Capacitor, 12000 mfd, 10V, Sprague Type 36D
C106		Capacitor, 100 mfd, 10V, Sprague Type 109D (on S106)
CR101		Diode, 1N4151 (on S105)
F1		Fuse, 1/4 Amp., Bussman Type MDL
FL101	8135	Filter, L.P.
J1		Connector, Switchcraft No. AC3G
J102 Thru J106		Connector, UG-657/U
LED101		Lamp, Monsanto No. MV-5023
M101	7331	Meter
Q3		Transistor, 2N1541
Q4,Q5		Transistor, MJ3000
R101		Resistor, 100 Megohms, ± 10%, 1/4W., A-B Type CB (on S102)
R102		Resistor, 10 Megohms, ± 10%, 1/4W, A-B Type CB (on S102)
R103		Resistor, 150 Ohms, ± 10%, 1/4W, A-B Type CB (on S107)
R104		Resistor, 1200 Ohms, ± 10%, 1/4, A-B Type CB (on S107)
R105		Resistor, 12K Ohms, ± 10%, 1/4W, A-B Type CB (on S107)
R106		Resistor, 2200 Ohms, ± 10%, 1/4W, A-B Type CB (on S107)
R107		Resistor, 909 Ohms, ± 1%, 1/8W, IRC No. CEA-TO (on S103)
R108		Resistor, 100 Ohms, ± 1%, 1/8W IRC No. CEA-TO (on S103)
R110		Resistor, Var., 10K Ohms, Beckman No. ARL25
R111		Resistor, Var., 50 Ohms, Linear Taper, A-B No. CMU-5001
R115		Resistor, 4020 Ohms, ± 1%, 1/8W, IRC No. CEA-TO (on S104/R118)
R116		Resistor, 8660 Ohms, ± 1%, 1/8W, IRC No. CEA-TO (on S104/R118)
R117		Resistor, 2740 Ohms, ± 1%, 1/8W, IRC No. CEA-TO (on S104/R118)
R119		Resistor, *(Factory Select) Ohms ± 1%, 1/8W, IRC No. CEA-TO (on S105)
R120		Resistor, 1000 Ohms, ± 10% 1/4W, A-B Type CB (on S107)
R122		Resistor, Var., 1000 Ohms, Linear Taper, A-B No. JA1L040S102 MC
R123		Resistor, 10K Ohms, ± 10%, 1/4W, A-B Type CB (on S106)
R124		Resistor, 100K Ohms, ± 10%, 1/4W, A-B Type CB (on S106)
R125		Resistor, 180K Ohms, ± 10%, 1/4W A-B Type CB (on S107)
R126		Resistor, 10K Ohms, ± 10%, 1/4W, A-B Type CB (on S107)
R127		Resistor, 1000 Ohms, ± 10%, 1/4W, A-B Type CB (on S107)
R151,R152		Resistor, Var., 1000 Ohms, Linear Taper, A-B Type J
R162,R163		Resistor, Var., 100K Ohms, Linear Taper, A-B Type WA
S1		Switch, Toggle, Alco No. MST-105D
S2		Switch, Slide, Switchcraft No. 11A-1007
S101		Switch, Toggle, Alco No. MST-215N
S102,S103	8159-2	Switch, Rotary
S104, R118	6051	Switch, Rotary & Resistor, Var.
S105	8160	Switch, Rotary
S106,S107	8159-3	Switch, Rotary
T1	7864	Transformer, Power
W1		Cordset, Belden No. 17258
P1,P2		Connector, Part of W1
Connector Board Components		
	8148	Board, P.C.
		Connector, Cinch Jones No. 250-22-30-170 (14 req'd.)
C101 Thru C105		0.01 mf, ± 20%, 100V Erie Type 811
C8, C9,C10		250 mf, 50V, Sprague No. TVA-1312
R112		10K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R113		Var. 2000 Ohms Beckman, No. 72XW2K
R114		10K Ohms, ± 1%, 1/8W, IRC No. CEA-TO





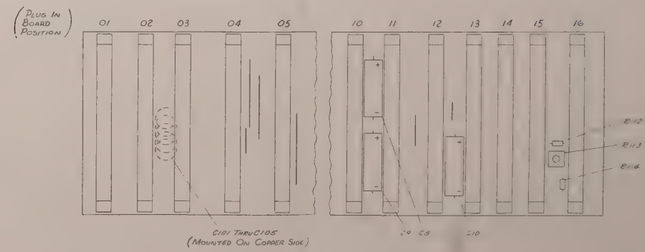
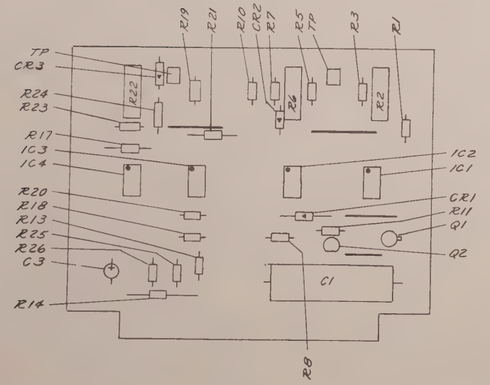
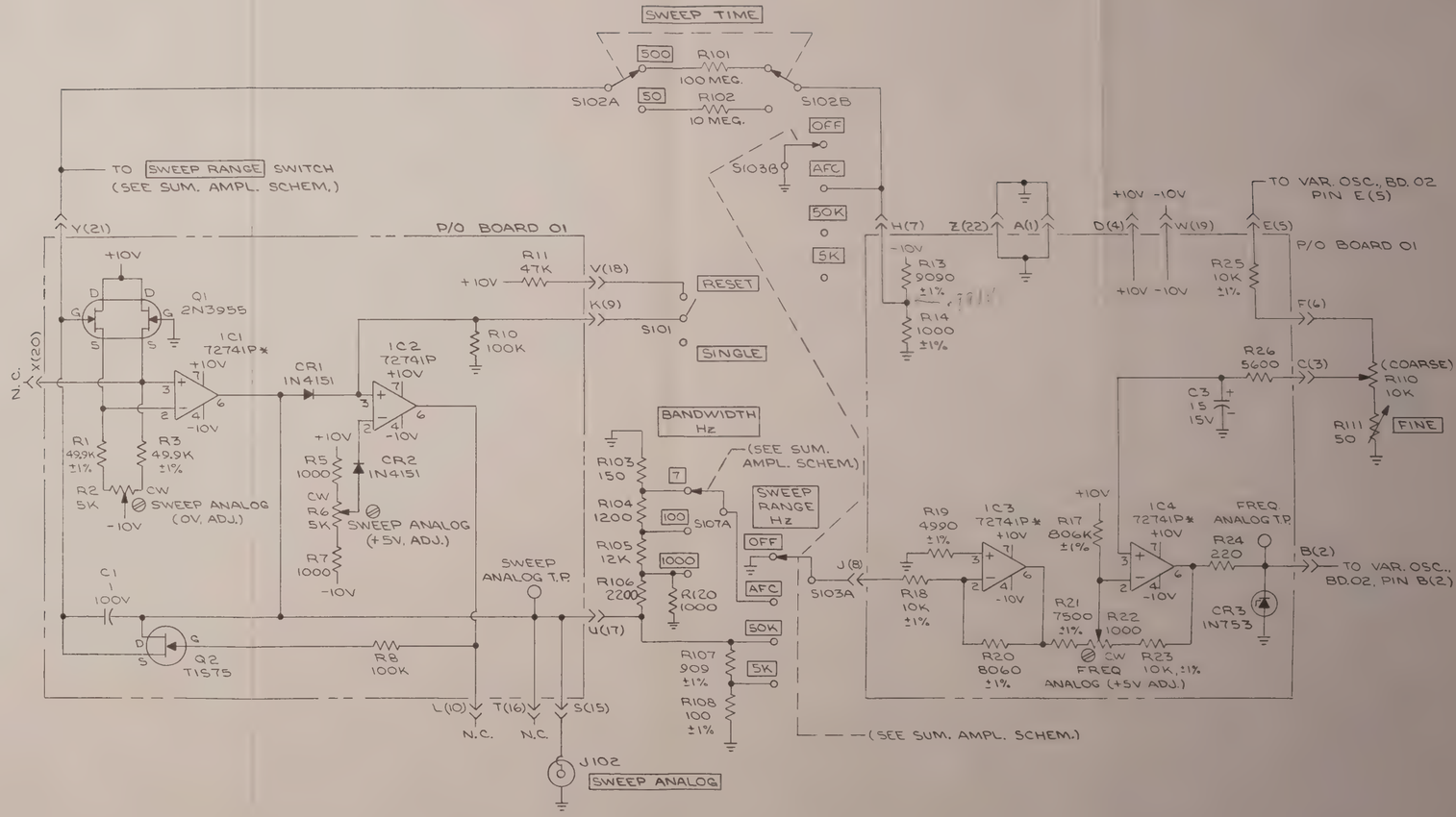


FIGURE 5-1. MAIN FRAME AND CONNECTOR BOARD

TABLE 5-2. REPLACEABLE PARTS LIST

SYMBOL	PART NO.	DESCRIPTION
	8025	Board, P.C.
		Ejector, SAE No. 6100 (2 req'd.)
C1		Capacitor, 1 mfd, ± 10%, 100V, Marshall No. D1-105E
C2		(Not Used)
C3		Capacitor, 15 mfd, ± 10%, 15V, Sprague Type 196D
CR1		Diode, 1N4151
CR2		Diode, 1N4151
CR3		Diode, 1N753
IC1	5651-2	Integrated Circuit, (72741P)
IC2	5651-1	Integrated Circuit, (72741P)
IC3	5651-2	Integrated Circuit, (72741P)
IC4	5651-2	Integrated Circuit, (72741P)
Q1	5621	FET, (2N3955)
Q2		FET, T1S75
R1		Resistor, 49.9K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R2		Resistor, Var., 5K Ohms, Beckman No. 79PR5K
R3		Resistor, 49.9K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R4		(Not Used)
R5		Resistor, 1000 Ohms, ± 10%, 1/4W, A-B Type CB
R6		Resistor, Var., 5K Ohms, Beckman No. 79PR5K
R7		Resistor, 1000 Ohms, ± 10%, 1/4W, A-B Type CB
R8		Resistor, 100K Ohms, ± 10%, 1/4W, A-B Type CB
R9		(Not Used)
R10		Resistor, 100K Ohms, ± 10%, A-B Type CB
R11		Resistor, 47K Ohms, ± 10%, 1/4W, A-B Type CB
R12		(Not Used)
R13		Resistor, 9090 Ohms, ± 1%, 1/8W, IRC No CEA-TO
R14		Resistor, 1000 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R15		(Not Used)
R16		(Not Used)
R17		Resistor, 806K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R18		Resistor, 10K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R19		Resistor, 4990 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R20		Resistor, 8060 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R21		Resistor, 7500 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R22		Resistor, Var., 1000 Ohms, Beckman No. 79PR1K
R23		Resistor, 10K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R24		Resistor, 220 Ohms, ± 10%, 1/4W, A-B Type CB
R25		Resistor, 10K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R26		Resistor, 5600 Ohms, ± 10%, 1/4W, A-B Type CB
TP		Test Point, E.F. Johnson No. 105-1101-001 (2 req'd.)



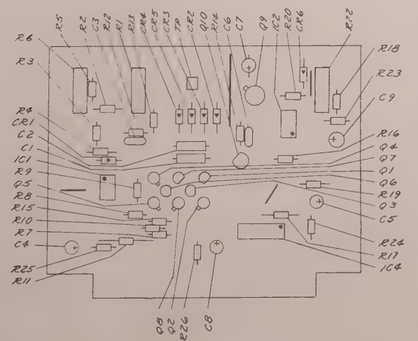


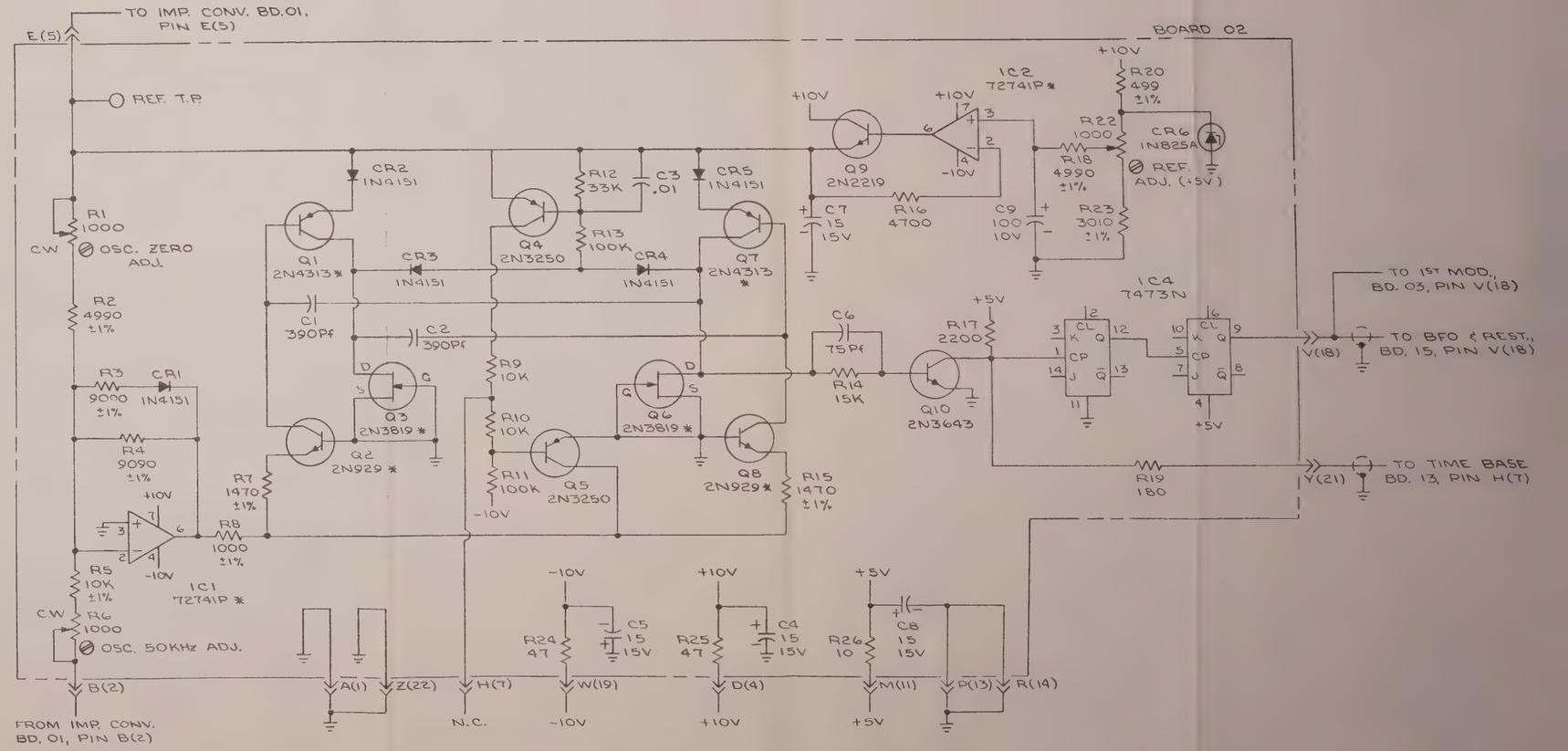
C-8421-A

FIGURE 5-2. SWEEP GENERATOR AND IMPEDANCE CONVERTER

TABLE 5-3. REPLACEABLE PARTS LIST

SYMBOL	PART NO.	DESCRIPTION
	8026	Board, P.C.
		Ejector, SAE No. 6100 (2 req'd.)
C1		Capacitor, 390 Pf, ±1%, 500V, CM15E391F
C2		Capacitor, 390 Pf, ±1%, 500V, CM15E391F
C3		Capacitor, 0.01 Mfd, ±20%, 1000V, Erie Type 811
C4		Capacitor, 15 Mfd, ±10%, 15V, Sprague Type 196D
C5		Capacitor, 15 Mfd, ±10%, 15V, Sprague Type 196D
C6		Capacitor, 75 Pf, ±10%, 1000V, Centralab No. DD-750
C7		Capacitor, 15 Mfd, ±10%, 15V, Sprague Type 196D
C8		Capacitor, 15 Mfd, ±10%, 15V, Sprague Type 196D
C9		Capacitor, 100 Mfd, ±20%, 10V, Sprague Type 196D
CR1 Thru CR5 CR6		Diode, 1N4151 Diode, 1N825A
IC1	5651-2	Integrated Circuit, (72741P)
IC2	5651-2	Integrated Circuit (72741P)
IC3		(Not Used)
IC4		Integrated Circuit 7473N
Q1	5647-2	Transistor, (2N4313)
Q2	5613-6	Transistor, (2N929 or 2N930)
Q3	5638-10-1	FET, (2N3819)
Q4	5620-1	Transistor, (2N3250)
Q5	5620-1	Transistor, (2N3250)
Q6	5638-10-1	FET, (2N3819)
Q7	5647-2	Transistor, (2N4313)
Q8	5613-6	Transistor, (2N929 or 2N930)
Q9	5619-1	Transistor, (2N2219)
Q10	5632-1	Transistor, (2N3643)
R1		Resistor, Var., 1000 Ohms, Beckman No. 79PR1K
R2		Resistor, 4990 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R3		Resistor, 9090 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R4		Resistor, 9090 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R5		Resistor, 10K Ohms, ±1%, 1/8W, IRC No. CEA-TO
R6		Resistor, Var., 1000 Ohms, Beckman No. 79PR1K
R7		Resistor, 1470 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R8		Resistor, 1000 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R9		Resistor, 10K Ohms, ±10%, 1/4W, A-B type CB
R10		Resistor, 10K Ohms, ±10%, 1/4W, A-B type, CB
R11		Resistor, 100K Ohms, ±10%, 1/4W, A-B type CB
R12		Resistor, 33K Ohms, ±10%, 1/4W, A-B type CB
R13		Resistor, 100K Ohms, ±10%, 1/4W, A-B type CB
R14		Resistor, 15K Ohms, ±10%, 1/4W, A-B type CB
R15		Resistor, 1470 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R16		Resistor, 4700 Ohms, ±10%, 1/4W, A-B type CB
R17		Resistor, 2200 Ohms, ±10%, 1/4W, A-B type CB
R18		Resistor, 4990 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R19		Resistor, 180 Ohms, ±10%, 1/4W, A-B type CB
R20		Resistor, 499 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R21		(Not Used)
R22		Resistor, Var., 1000 Ohms, Beckman No. 79PR1K
R23		Resistor 3010 Ohms, ±1% 1/8W, IRC No. CEA-TO
R24		Resistor, 47 Ohms, ±10%, 1/4W, A-B type CB
R25		Resistor, 47 Ohms, ±10%, 1/4W, A-B type CB
R26		Resistor, 10 Ohms, ±10%, 1/4W, A-B type CB
TP		Test Point, E.F. Johnson No. 105-1101-001





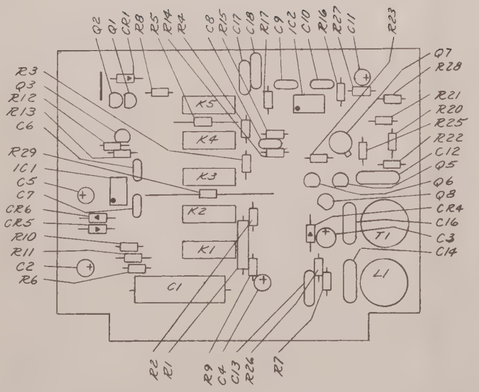
T-8422-A

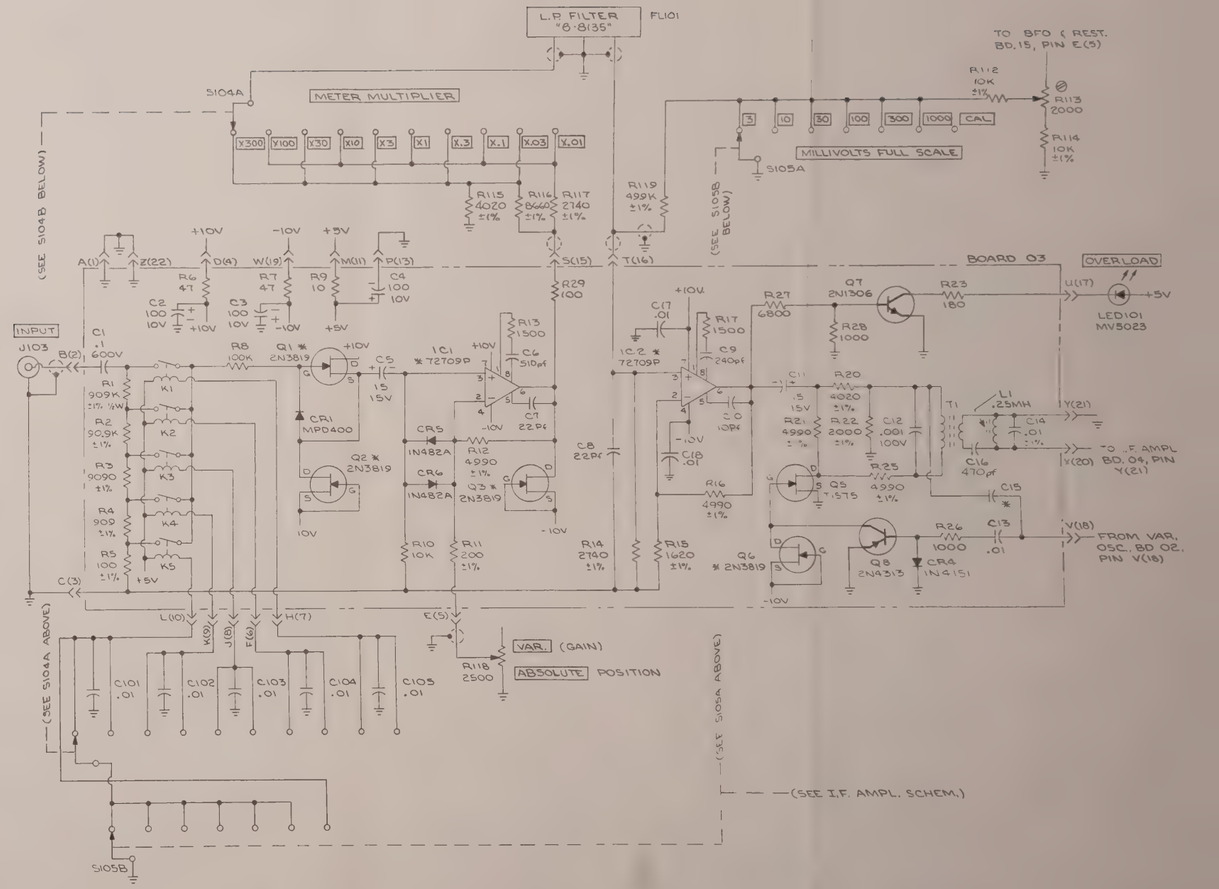
FIGURE 5-3. VARIABLE OSCILLATOR

TABLE 5-4. REPLACEABLE PARTS LIST

SYMBOL	PART NO.	DESCRIPTION
	8027	Board, P.C.
		Ejector, SAE No. 6100 (2 req'd.)
C1		Capacitor, 0.1 mfd, ± 10%, 600V, Marshall No. D6-104E
C2		Capacitor, 100 mfd, ± 20%, 10V, Sprague Type 196D
C3		Capacitor, 100 mfd, ± 20%, 10V, Sprague Type 196D
C4		Capacitor, 100 mfd, ± 20%, 10V, Sprague Type 196D
C5		Capacitor, 15 mfd, ± 10%, 15V, Sprague Type 196D
C6		Capacitor, 510 Pf, ± 10%, 1000V, Centralab No. DD-511
C7		Capacitor, 22 Pf, ± 10%, 1000V, Centralab No. DD-220
C8		Capacitor, 22 Pf, ± 10%, 1000V, Centralab No. DD-220
C9		Capacitor, 240 Pf, ± 10%, 1000V, Centralab No. DD-241
C10		Capacitor, 10 Pf, ± 10%, 1000V, Centralab No. DD-100
C11		Capacitor, 15 mfd, ± 10%, 15V, Sprague Type 196D
C12		Capacitor, 0.001 mfd, ± 1%, 100V, Arco Type MPD
C13		Capacitor, 0.01 mfd, ± 20%, 1000V, Erie Type 811
C14		Capacitor, 0.01 mfd, ± 10%, 100V, Arco Type MPD
C15		Capacitor, *(Factory Select)
C16		Capacitor, 470 Pf, ± 1%, 300V Arco Type DM 15
C17		Capacitor, 0.01 mfd, ± 20%, 1000V, Erie Type 811
C18		Capacitor, 0.01 mfd, ± 20%, 1000V, Erie Type 811
CR1		Diode, MPD400
CR2		(Not Used)
CR3		(Not Used)
CR4		Diode, 1N4151
CR5		Diode, 1N482A
CR6		Diode, 1N482A
IC1	5650-2	Integrated Circuit, (72709P)
IC2	5650-2	Integrated Circuit (72709P)
K1		Relay, Grigsby — Barton No. 814A-2B or 831A-3
K2		Relay, Grigsby — Barton No. 814A-2B or 831A-3
K3		Relay, Grigsby — Barton No. 814A-2B or 831A-3
K4		Relay, Grigsby — Barton No. 814A-2B or 831A-3
K5		Relay, Grigsby — Barton No. 814A-2B or 831A-3
L1	8079	Coil
Q1	5638-4-2	FET, (2N3819)
Q2	5638-3-2	FET, (2N3819)

SYMBOL	PART NO.	DESCRIPTION
Q3	5638-6-1	FET, (2N3819)
Q4		(Not Used)
Q5		FET, T1S 75
Q6	5638-10-1	FET, (2N3819)
Q7	5616-1	Transistor (2N1306)
Q8	5647-1	Transistor, (2N4313)
R1		Resistor, 909K Ohms, ± 1%, 1/2W, IRC No. CEC-TO
R2		Resistor, 90.9K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R3		Resistor, 9090 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R4		Resistor, 909 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R5		Resistor, 100 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R6		Resistor, 47 Ohms, ± 10%, 1/4W, A-B Type CB
R7		Resistor, 47 Ohms, ± 10%, 1/4W, A-B Type CB
R8		Resistor, 100K Ohms, ± 10%, 1/4W, A-B Type CB
R9		Resistor, 10 Ohms, ± 10%, 1/4W, A-B Type CB
R10		Resistor, 10K Ohms, ± 10%, 1/4W, A-B Type CB
R11		Resistor, 200 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R12		Resistor, 4990 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R13		Resistor, 1500 Ohms, ± 10%, 1/4W, A-B Type CB
R14		Resistor, 2740 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R15		Resistor, 1620 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R16		Resistor, 4990 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R17		Resistor, 1500 Ohms, ± 10%, 1/4W, A-B Type CB
R18		(Not Used)
R19		(Not Used)
R20		Resistor, 2000 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R21		Resistor, 4990 Ohms ± 1%, IRC No. CEA-TO
R22		Resistor, 2000 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R23		Resistor, 180 Ohms, ± 10%, 1/4W, A-B Type CB
R24		(Not Used)
R25		Resistor, 4990 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R26		Resistor, 1000 Ohms, ± 10%, 1/4W, A-B Type CB
R27		Resistor, 6800 Ohms, ± 10%, 1/4W, A-B Type CB
R28		Resistor, 1000 Ohms, ± 10%, 1/4W, A-B Type CB
R29		Resistor, 1000 Ohms ± 10%, 1/4W, A-B Type CB
T1	8078	Transformer





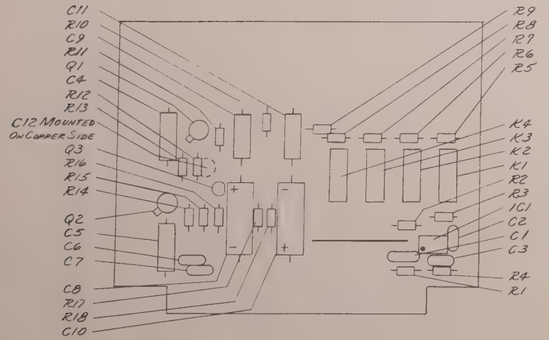
C-8423-A

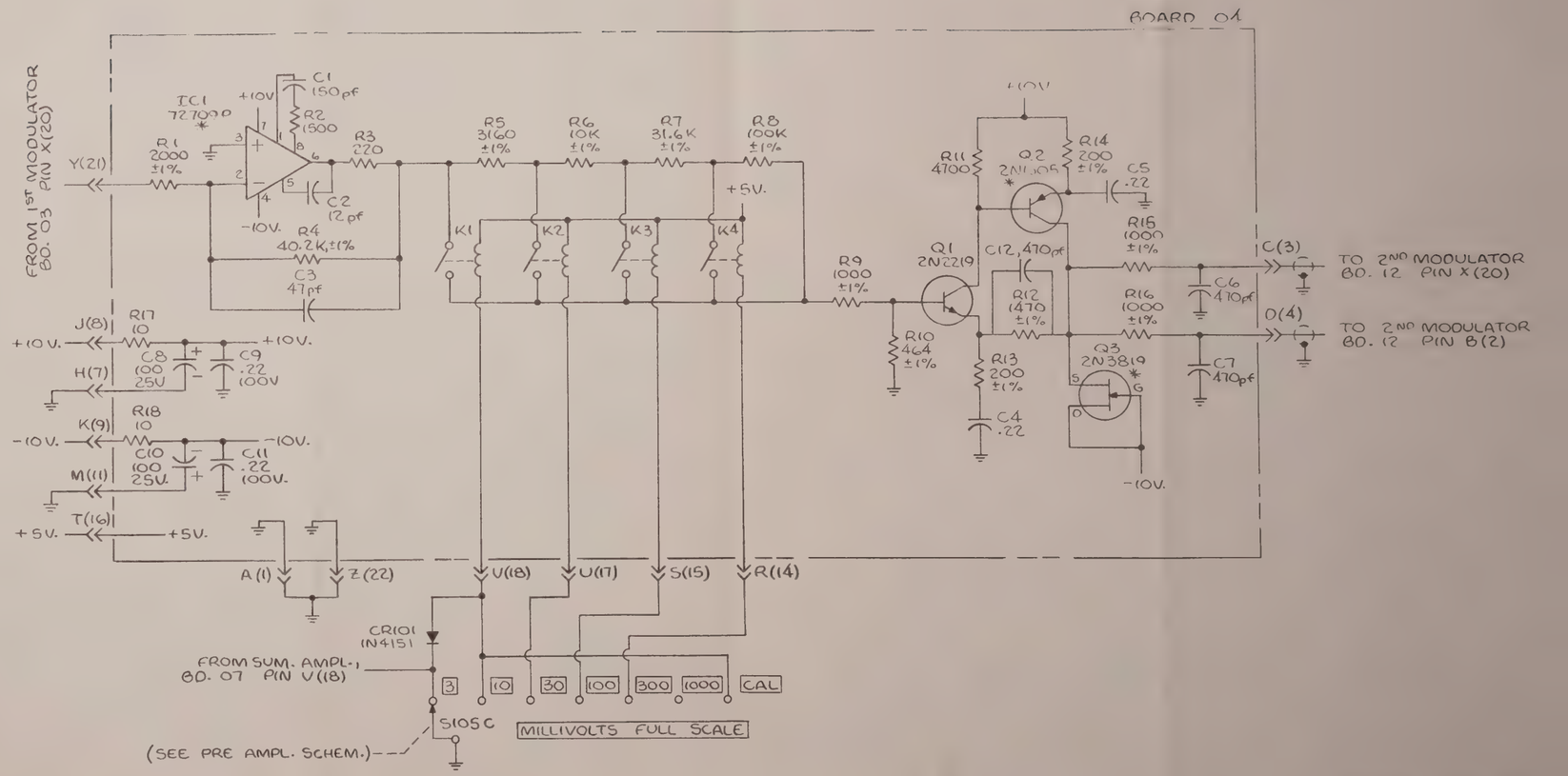
FIGURE 5-4. PREAMPLIFIER AND 1st MODULATOR

TABLE 5-5. REPLACEABLE PARTS LIST

SYMBOL	PART NO.	DESCRIPTION
	8146	Board, P.C.
		Ejector, SAE No. 6100 (2 req'd.)
C1		Capacitor, 150 Pf, ±10%, 500V, Arco No. CM05FD151KO3
C2		Capacitor, 12 Pf, ±10%, 1000V, Centralab No. DD-120
C3		Capacitor, 47 Pf, ±10%, 1000V, Centralab No. DD-470
C4		Capacitor, 0.22 Mfd, ±10%, 100V, Marshall No. D1
C5		Capacitor, 0.22 Mfd, ±10%, 100V, Marshall No. D1
C6		Capacitor, 470 Pf, ±5%, 500V, Arco No. CM20
C7		Capacitor, 470 Mfd, 5%, 500V, Arco No. CM20
C8		Capacitor, 100 Mfd, 25V, Sprague No. TE-1211
C9		Capacitor, 0.22 Mfd, ±10%, 100V, Marshall No. D1
C10		Capacitor, 100 Mfd, 25V, Sprague No. TE-1211
C11		Capacitor, 0.22 Mfd, ±10%, 100V, Marshall No. D1
C12		Capacitor, 470 Pf, ± 10%, 1000V, Centralab, No DD-471
IC1	5650-2	Integrated Circuits (72709P)
K1		Relay, Grigsby — Barton No. 814A-2B or No. 831A-3
K2		Relay, Grigsby — Barton No. 814A-2B or No. 831A-3
K3		Relay, Grigsby — Barton No. 814A-2B or No. 831A-3
K4		Relay, Grigsby — Barton No. 814A-2B or No. 831A-3
Q1	5619-1	Transistor (2N2219)
Q2	5612-2	Transistor (2N1305)
Q3	5638-8-2	Transistor (2N3819)

SYMBOL	PART NO.	DESCRIPTION
R1		Resistor, 2000 Ohm, ±1%, 1/8W, IRC No. CEA-TO
R2		Resistor, 1500 Ohms, ±10%, 1/4W, A-B type CB
R3		Resistor, 220 Ohms, ±10%, 1/4W, A-B type CB
R4		Resistor, 19.6K Ohms, ±1%, 1/8W, IRC No. CEA-TO
R5		Resistor, 40.2K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R6		Resistor 10K Ohms, ±1%, 1/8W, IRC No. CEA-TO
R7		Resistor, 31.6K Ohms, ±1%, 1/8W, IRC No. CEA-TO
R8		Resistor, 100K Ohms, ±1%, 1/8W, IRC No. CEA-TO
R9		Resistor, 100 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R10		Resistor, 464 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R11		Resistor, 4700 Ohms, ±10%, 1/4W, A-B type CB
R12		Resistor, 1470 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R13		Resistor, 200 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R14		Resistor, 200 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R15		Resistor, 1000 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R16		Resistor, 1000 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R17		Resistor, 10 Ohms, ±10%, 1/4W, A-B type CB
R18		Resistor, 10 Ohms, ±10%, 1/4W, A-B type CB





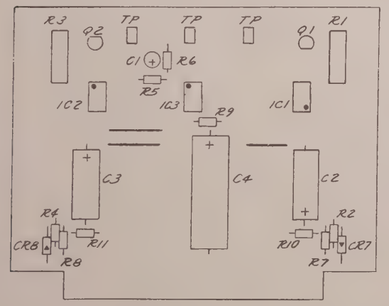
T-8424-A

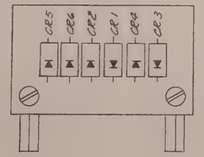
FIGURE 5-5. IF AMPLIFIER

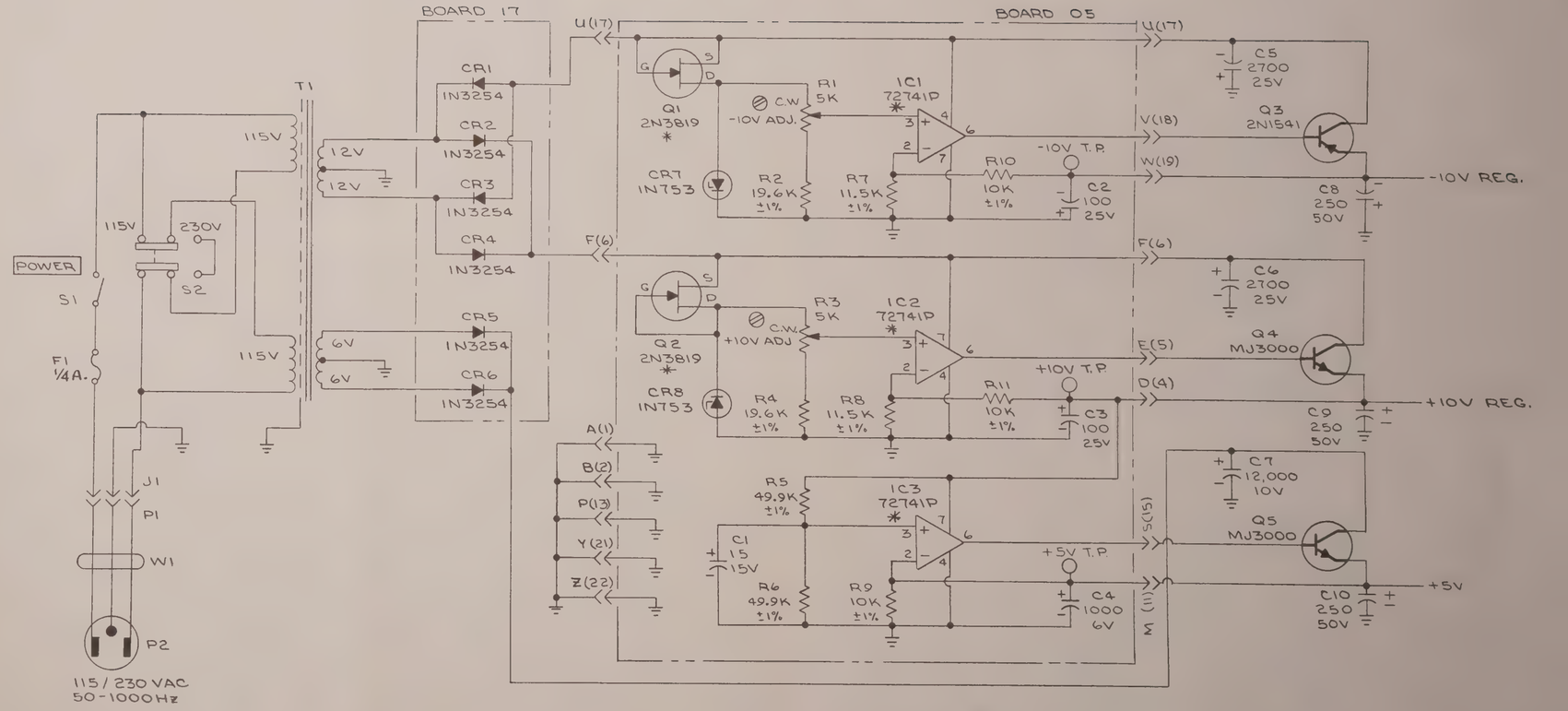
TABLE 5-6. REPLACEABLE PARTS LIST

SYMBOL	PART NO.	DESCRIPTION
Power Supply		
	8029	Board, P.C.
		Ejector, SAE No. 6100 (2 req'd.)
C1		Capacitor, 15 mfd, ± 10%, 15V, Sprague Type
C2		Capacitor, 100 mfd, 25V, Sprague No. TE-1211
C3		Capacitor, 100 mfd, 25V, Sprague No. TE-1211
C4		Capacitor, 1000 mfd, 6V, Richey
CR1 Thru CR6		(Not Used)
CR7		Diode, 1N753
CR8		Diode, 1N753
IC1	5651-2	Integrated Circuit, (72741P)
IC2	5651-2	Integrated Circuit, (72741P)
IC3	5651-2	Integrated Circuit, (72741P)
Q1	5638-4-1	FET, (2N3819)
Q2	5638-4-1	FET, (2N3819)
R1		Resistor, Var., 5K Ohms, Beckman No. 79PR5K
R2		Resistor, 19.6K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R3		Resistor, Var., 5K Ohms, Beckman No. 79PR5K
R4		Resistor, 19.6K Ohms, ± 1%, 1/8W, IRC No. CEA-TO

SYMBOL	PART NO.	DESCRIPTION
R5		Resistor, 49.9K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R6		Resistor, 49.9K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R7		Resistor, 11.5K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R8		Resistor, 11.5K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R9		Resistor, 10K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R10		Resistor, 10K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R11		Resistor, 10K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
TP		Test Point, E.F. Johnson No. 105-1101-001 (3 req'd)
Rectifier		
		Board, P.C.
		Spade Bolt No. FSP-882W (2 req'd.)
		Spacer, Smith No. 2322 (2 req'd.)
CR1		Rectifier, IN3254
CR2		Rectifier, IN3254
CR3		Rectifier, IN3254
CR4		Rectifier, IN3254
CR5		Rectifier, IN3254
CR6		Rectifier, IN3254







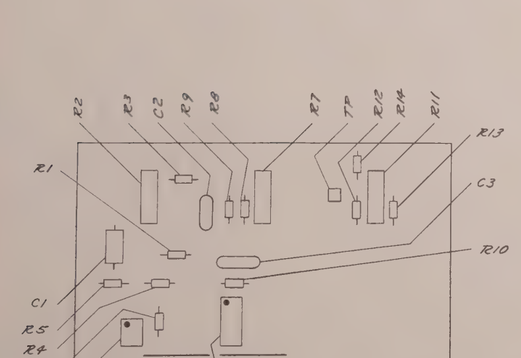
T-8425-A

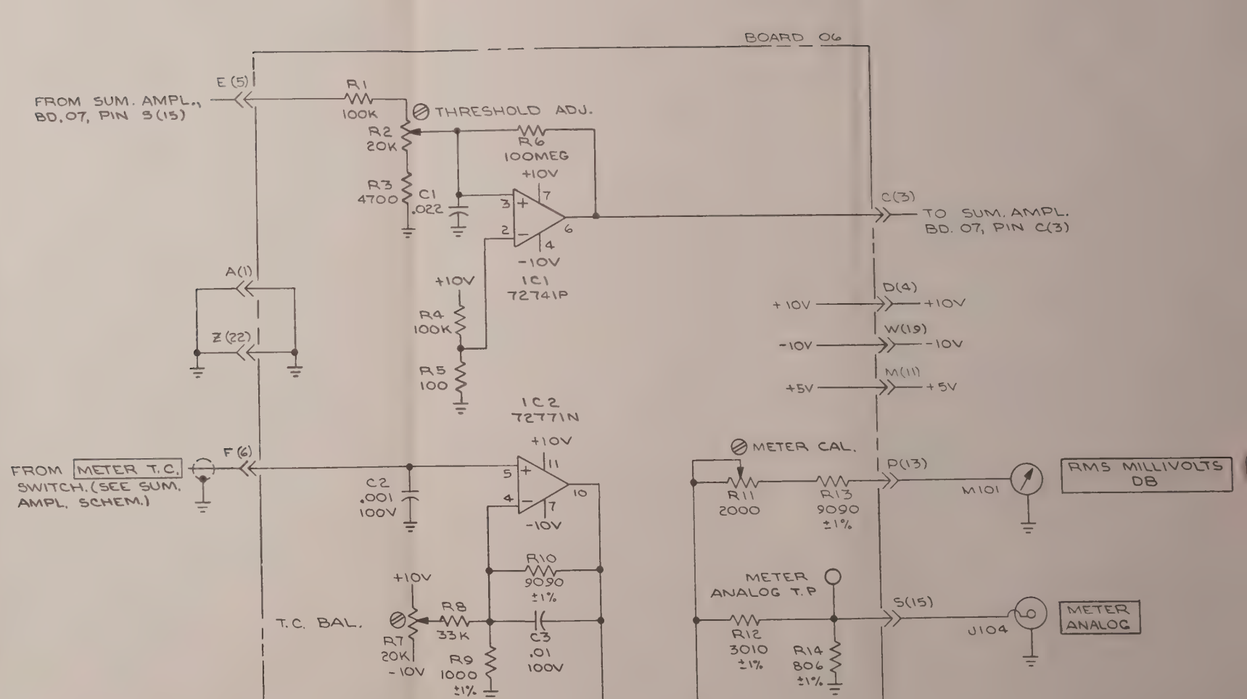
FIGURE 5-6. POWER SUPPLY AND RECTIFIER

TABLE 5-7. REPLACEABLE PARTS LIST

SYMBOL	PARTS NO.	DESCRIPTION
	8030	Board, P.C.
	8147	Ejector, SAE No. 6100 (2 req'd.)
C1		Capacitor, 0.022 Mfd, ± 10%, 100V, Marshall No. D1-223E
C2		Capacitor, 0.001 Mfd, ± 5%, 100V, Arco Type MPD
C3		Capacitor, 0.01 Mfd, ± 10%, 100V, Arco Type MPD
IC1	5651-2	Integrated Circuit (72741P)
IC2	5652-1	Integrated Circuit (72771N)
R1		Resistor, 100K Ohms, ± 10%, 1/4W, A-B type CB
R2		Resistor, Var., 20K Ohms, Beckman No. 79PR20K
R3		Resistor, 4700 Ohms, ± 10%, 1/4W, A-B type CB
R4		Resistor, 100K Ohms, ± 10%, 1/4W, A-B type CB
R5		Resistor, 100 Ohms, ± 10%, 1/4W, A-B type CB

SYMBOL	PART NO.	DESCRIPTION
R6		Resistor, 100 Megohms, ± 10%, 1/4W, A-B type CB
R7		Resistor, Var., 20K Ohms, Beckman No. 79PR20K
R8		Resistor, 33K Ohms, ± 10%, 1/4W, A-B type CB
R9		Resistor, 1000 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R10		Resistor, 9090 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R11		Resistor, Var., 2K Ohms, Beckman No. 70PR2K
R12		Resistor, 3010 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R13		Resistor, 9090 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R14		Resistor, 806 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
TP		Test Point, E.F. Johnson No. 105-1101-001 (1 req'd.)





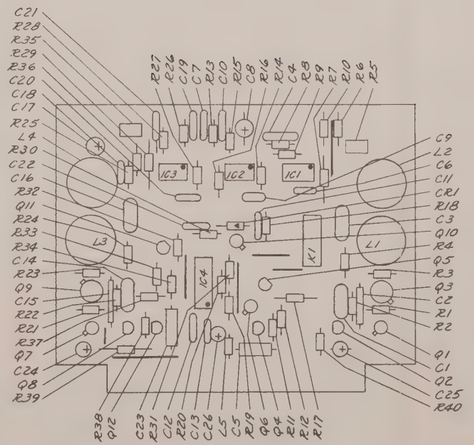
T-8426-A

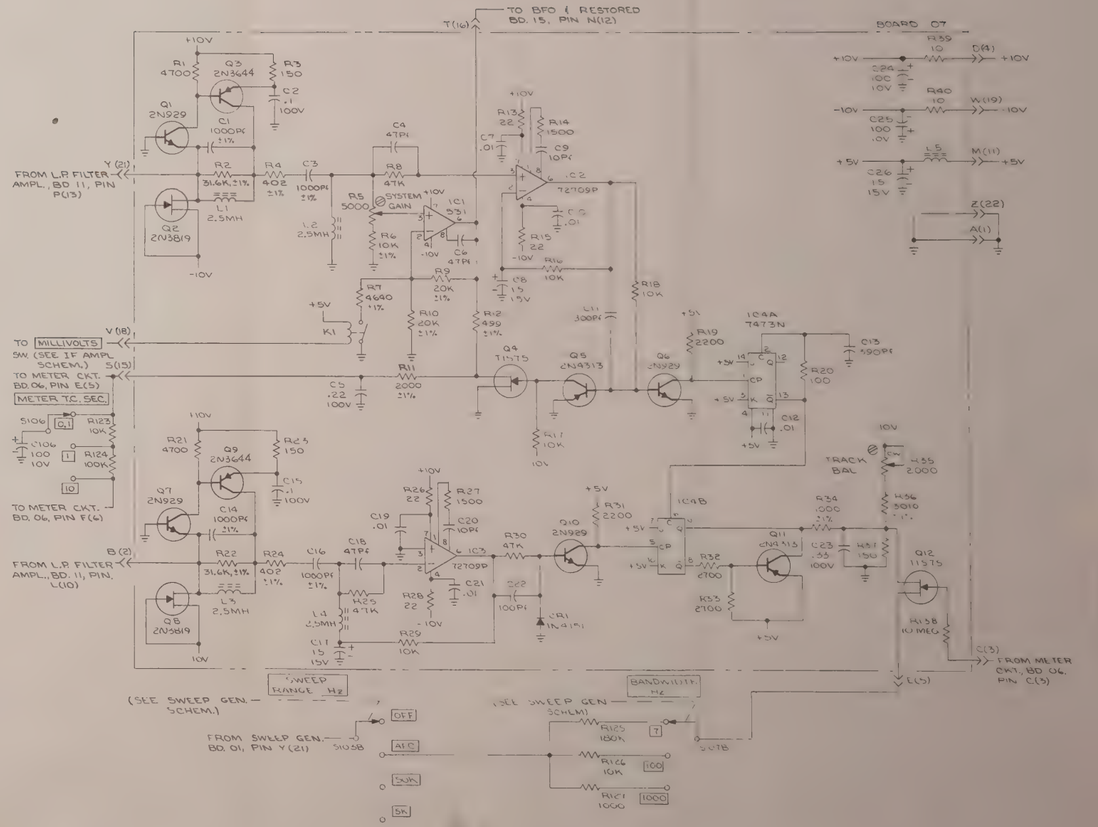
FIGURE 5-7. METER CIRCUIT

TABLE 5-8. REPLACEABLE PARTS LIST

SYMBOL	PART NO.	DESCRIPTION
	8231	Board, P.C.
		Ejector, SAE No. 6100 (2 req'd).
C1		Capacitor, 1000 Pf, ±1%, 100V
C2		Capacitor, 0.1 Mfd, ±10%, 100V, Marshall No. D1-104E
C3		Capacitor, 1000 Pf, ±1%, 100V
C4		Capacitor, 47 Pf, ±10%, 1000V, Centralab No. DD-470
C5		Capacitor, 0.22 Mfd, ±10%, 100V, Marshall No. D1-224E
C6		Capacitor, 47 Pf, ±10%, 1000V, Centralab No. DD-470
C7		Capacitor, 0.01 Mfd, ±20%, 1000V, Erie Type 811
C8		Capacitor, 15 Mfd, ±10%, 15V, Sprague Type 196D
C9		Capacitor, 10 Pf, ±10%, 1000V, Centralab No. DD-100
C10		Capacitor, 0.01 Mfd, ±20%, 1000V, Erie Type 811
C11		Capacitor, 300 Pf, ±10%, 1000V, Centralab No. DD-301
C12		Capacitor, 0.01 Mfd, ±20%, 1000V, Erie Type 811
C13		Capacitor, 270 Pf, ±5%, 100V, Arco No. DM-15
C14		Capacitor, 1000 Pf, ±1%, 100V Arco No. DM-15
C15		Capacitor, 0.1 Mfd, ±10%, 100V, Marshall No. D1-104E
C16		Capacitor, 1000 Pf, ±1%, 100V, Arco No. DM-15
C17		Capacitor, 15 Mfd, ±10%, 15V Sprague Type 196D
C18		Capacitor, 47 Pf, ±10%, 1000V, Centralab No. DD-470
C19		Capacitor, 0.01 Mfd, ±20%, 1000V, Erie Type 811
C20		Capacitor, 10 Pf, ±10%, 1000V, Centralab No. DD-100
C21		Capacitor, 0.01 Mfd, ±20%, 1000V, Erie Type 811
C22		Capacitor, 100 Pf, ±10%, 1000V, Centralab No. DD-101
C23		Capacitor, 0.33 Mfd, ±10%, 100V, Marshall No. D1-334E
C24		Capacitor, 100 Mfd, ±20%, 10V, Sprague Type 196D
C25		Capacitor, 100 Mfd, ±20%, 10V, Sprague Type 196D
C26		Capacitor, 15 Mfd, ±10%, 15V, Sprague Type 196D
CR1		Diode, 1N4151
IC1	5653-1	Integrated Circuit, (531)
IC2	5650-1	Integrated Circuit, (72709P)
IC3	5650-2	Integrated Circuit, (72709P)
IC4		Integrated Circuit 7473N
K1		Relay, Grigsby – Barton No. 814A-2B or No. 231A-3
L1	8058	Coil
L2	8058	Coil
L3	8058	Coil
L4	8058	Coil
L5	7387	Coil
Q1	5613-1	Transistor, (2N929) or (2N930)
Q2	5638-1-1	FET, (2N3819)
Q3	5626-1	Transistor (2N3644)
Q4		FET, T1S75
Q5	5647-1	Transistor, (2N4313)
Q6	5613-1	Transistor, (2N929) or (2N930)
Q7	5613-1	Transistor, (2N929) or (2N930)
Q8	5638-1-1	FET (2N3819)
Q9	5626-1	Transistor (2N3644)
Q10	5613-1	Transistor (2N929) or (2N930)
Q11	5647-1	Transistor (2N4313)
Q12		FET, T1S 75

SYMBOL	PART NO.	DESCRIPTION
R1		Resistor, 4700 Ohms, ±10%, 1/4W, A-B type CB
R2		Resistor, 31.6K Ohms, ±1%, 1/8W, IRC No. CEA-TO
R3		Resistor, 150 Ohms, ±10%, 1/4W, A-B type CB
R4		Resistor, 402 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R5		Resistor, Var., 5K Ohms, Beckman No. 72XWR5K
R6		Resistor, 10K Ohms, ±1%, 1/8W, IRC No. CEA-TO
R7		Resistor, 4640 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R8		Resistor, 47K Ohms, ±10%, 1/4W, A-B type CB
R9		Resistor, 20K Ohms, ±1%, 1/8W, IRC No. CEA-TO
R10		Resistor, 20K Ohms, ±1%, 1/8W, IRC No. CEA-TO
R11		Resistor, 2K Ohms, ±1%, 1/8W, IRC No. CEA-TO
R12		Resistor, 499 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R13		Resistor, 22 Ohms, ±10%, 1/4W, A-B type CB
R14		Resistor, 1500 Ohms, ±10%, 1/4W, A-B type CB
R15		Resistor, 22 Ohms, ±10%, 1/4W, A-B type CB
R16		Resistor, 10K Ohms, ±10%, 1/4W, A-B type CB
R17		Resistor, 10K Ohms, ±10%, 1/4W, A-B type CB
R18		Resistor, 10K Ohms, ±10%, 1/4W, A-B type CB
R19		Resistor, 2200 Ohms, ±10%, 1/4W, A-B type CB
R20		Resistor, 100 Ohms, ±10%, 1/4W, A-B type CB
R21		Resistor, 4700 Ohms, ±10%, 1/4W, A-B type CB
R22		Resistor, 31.6K Ohms, ±1%, 1/8W, IRC No. CEA-TO
R23		Resistor, 150 Ohms, ±10%, 1/4W, A-B type CB
R24		Resistor, 402 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R25		Resistor, 47K Ohms, ±10%, 1/4W, A-B type CB
R26		Resistor, 22 Ohms, ±10%, 1/4W, A-B type CB
R27		Resistor, 1500 Ohms, ±10%, 1/4W, A-B type CB
R28		Resistor, 22 Ohms, ±10%, 1/4W, A-B type CB
R29		Resistor, 10K Ohms, ±10%, 1/4W, A-B type CB
R30		Resistor, 47K Ohms, ±10%, 1/4W, A-B type CB
R31		Resistor, 2200 Ohms, ±10%, 1/4W, A-B type CB
R32		Resistor, 2700 Ohms, ±10%, 1/4W, A-B type CB
R33		Resistor, 2700 Ohms, ±10%, 1/4W, A-B type CB
R34		Resistor, 1000 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R35		Resistor, Var., 2K Ohms, Beckman No. 72XWR2K
R36		Resistor, 3010 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R37		Resistor, 150 Ohms, ±10%, 1/4W, A-B type CB
R38		Resistor, 10 Megohms, ±10%, 1/4W, A-B type CB
R39		Resistor, 10 Ohms, ±10%, 1/4W, A-B type CB
R40		Resistor, 10 Ohms, ±10%, 1/4W, A-B type CB



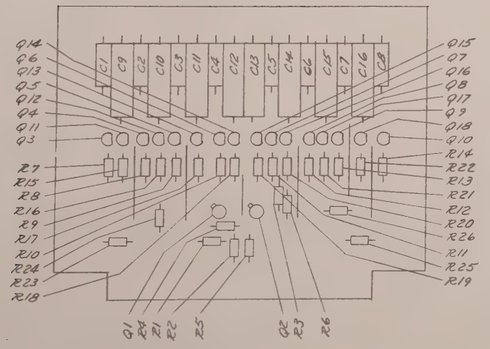


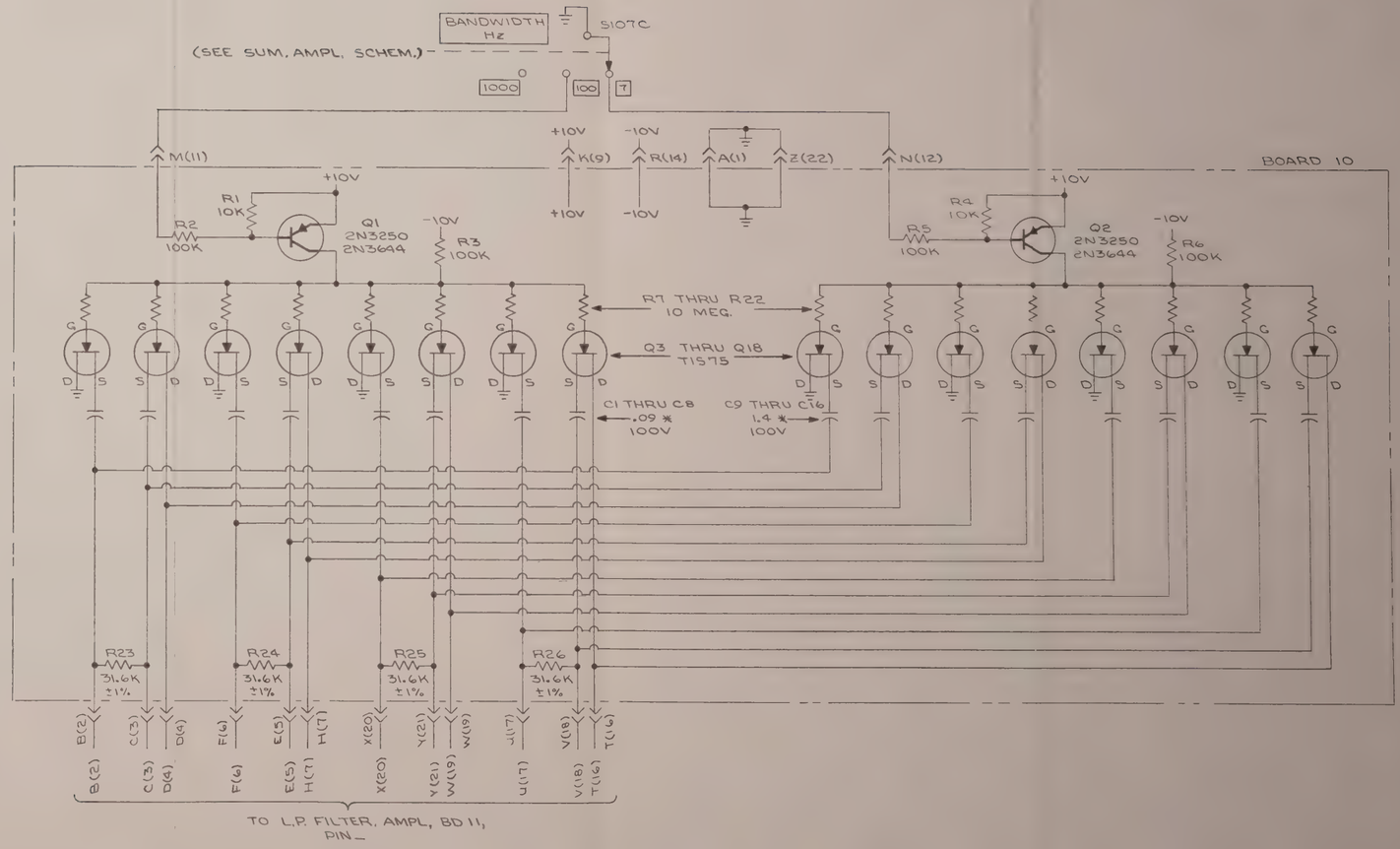
C-8427-A

FIGURE 5-8. SUMMING AMPLIFIER AND DETECTOR

TABLE 5-9. REPLACEABLE PARTS LIST

SYMBOL	PART NO.	DESCRIPTION
	8034	Board, P.C.
		Ejector, SAE No. 6100 (2 req'd.)
C1 Thru C8	5643-20	Capacitor (0.09 Mfd)
C9 Thru C16	5643-10	Capacitor (1.4 Mfd)
Q1	5620-1	Transistor (2N3250)
Q2	5620-1	Transistor (2N3250)
Q3 Thru Q18		FET T1S75
R1		Resistor, 10K Ohms, ±10%, 1/4W, A-B type CB
R2		Resistor, 100K Ohms, ±10%, 1/4W, A-B type CB
R3		Resistor, 100K Ohms, ±10%, 1/4W, A-B type CB
R4		Resistor, 10K Ohms, ±10%, 1/4W, A-B type CB
R5		Resistor, 100K Ohms, ±10%, 1/4W, A-B type CB
R6		Resistor, 100K Ohms, ±10%, 1/4W, A-B type CB
R7 Thru R22		Resistor 10 Megohms, ±10%, 1/4W, A-B type CB
R23 Thru R26		Resistor 31.6K Ohms, ±1%, 1/4W, IRC No. CEA-TO



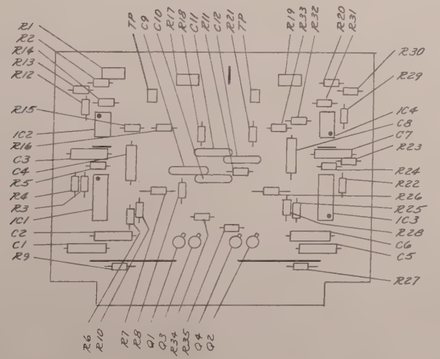


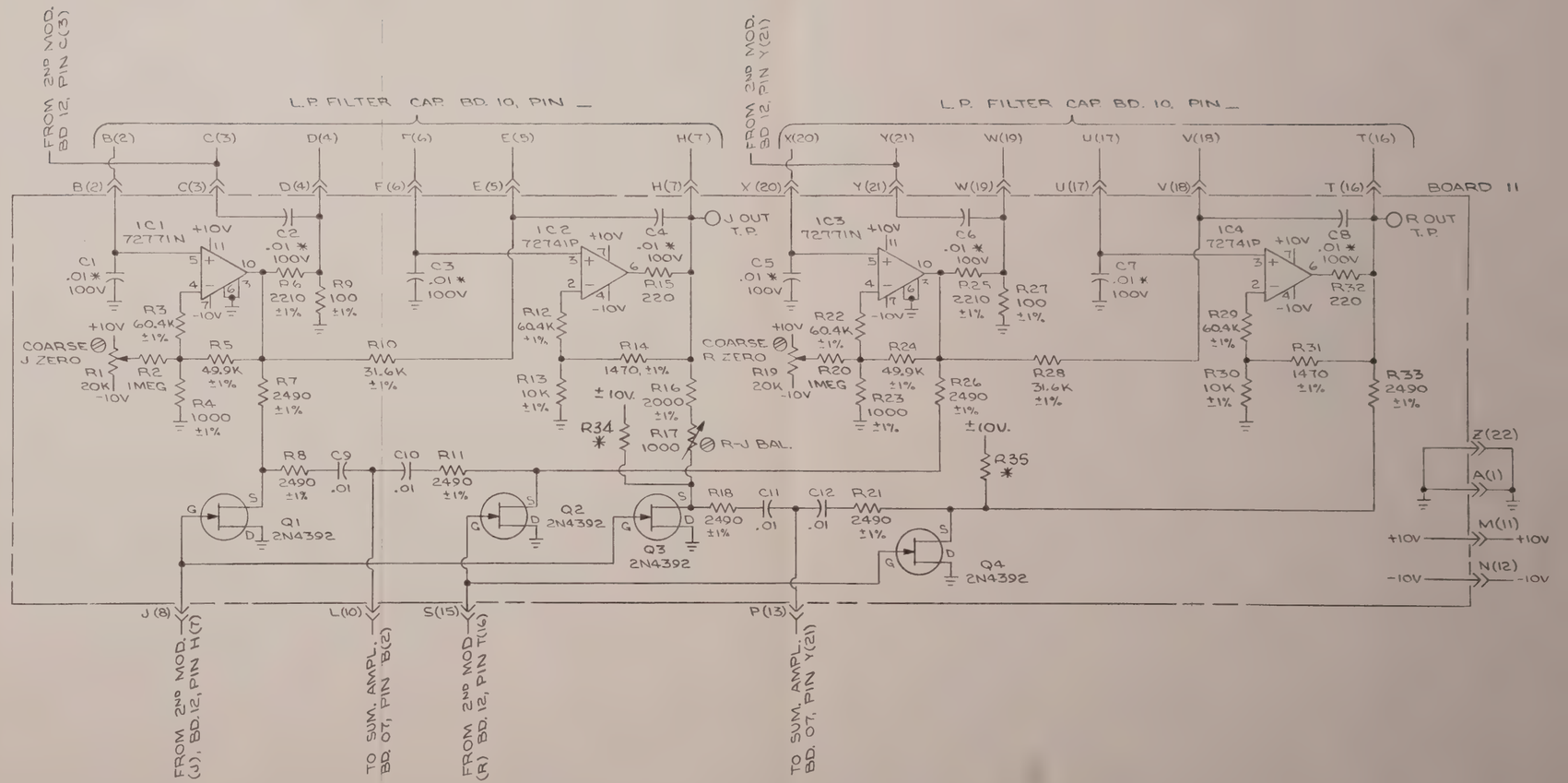
C-8430-A

FIGURE 5-9. LP FILTER CAPACITOR

TABLE 5-10. REPLACEABLE PARTS LISTS

SYMBOL	PART NO.	DESCRIPTION
	8035	Board, P.C.
		Ejector, SAE No. 6100 (2 req'd.)
C1 Thru C8 C9 Thru C12	5643-11	Capacitor, 0.01 Mfd Capacitor 0.01 Mfd, ±10%, 1000V, Erie Type 811
IC1	5652-1	Integrated Circuit, (72771N)
IC2	5651-1	Integrated Circuit, (72741P)
IC3	5652-1	Integrated Circuit, (72771N)
IC4	5651-1	Integrated Circuit, (72741P)
Q1 Thru Q4		FET 2N4392
R1		Resistor, Var., 20K Ohms, Beckman No. 72XWR20K
R2		Resistor, 1 Megohm, ±10%, 1/4W, A-B type CB
R3		Resistor, 60.4K Ohms, ±1%, 1/8W, IRC No. CEA-TO
R4		Resistor, 1000 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R5		Resistor, 49.9K Ohms, ±1%, 1/8W, IRC No. CEA-TO
R6		Resistor, 2210 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R7		Resistor, 2490 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R8		Resistor, 2490 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R9		Resistor, 100 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R10		Resistor, 31.6K Ohms, ±1% 1/8W, IRC No. CEA-TO
R11		Resistor, 2490 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R12		Resistor, 60.4K Ohms, ±1% 1/8W, IRC No. CEA-TO
R13		Resistor, 10K Ohms, ±1%, 1/8W, IRC No. CEA-TO
R14		Resistor, 1470 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R15		Resistor, 220 Ohms, ±10%, 1/4W, A-B type CB
R16		Resistor, 2000 Ohms, ±1% 1/8W, IRC No. CEA-TO
R17		Resistor, Var., 1000 Ohms, Beckman No. 72XWR1K
R18		Resistor, 2490 Ohms, ±1%, 1/8W, ICR No. CEA-TO
R19		Resistor, Var., 20K Ohms, Beckman No. 72XWR20K
R20		Resistor 1 Megohm, ±10%, 1/4W, A-B type CB
R21		Resistor 2490 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R22		Resistor, 60.4K Ohms, ±1%, 1/8W, IRC No. CEA-TO
R23		Resistor, 1000 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R24		Resistor, 49.9K Ohms, ±1%, 1/8W, IRC No. CEA-TO
R25		Resistor, 2210 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R26		Resistor, 2490 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R27		Resistor, 100 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R28		Resistor, 31.6K Ohms, ±1%, 1/8W, IRC No. CEA-TO
R29		Resistor, 60.4K Ohms, ±1%, 1/8W, IRC No. CEA-TO
R30		Resistor, 10K Ohms, ±1%, 1/8W, IRC No. CEA-TO
R31		Resistor, 1470 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R32		Resistor, 220 Ohms, ±10%, 1/4W, A-B type CB
R33		Resistor, 2490 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R34		Resistor, *(Factory Select)
R35		Resistor, *(Factory Select)
TP		Test Point, E.F. Johnson No. 105-1101-001 (2 req'd.)





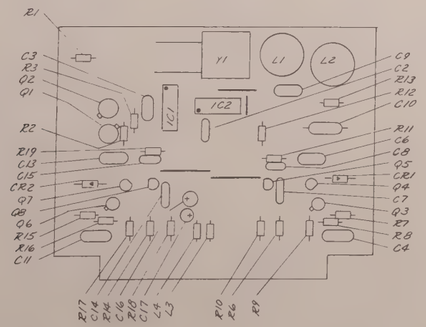
T-8431-A

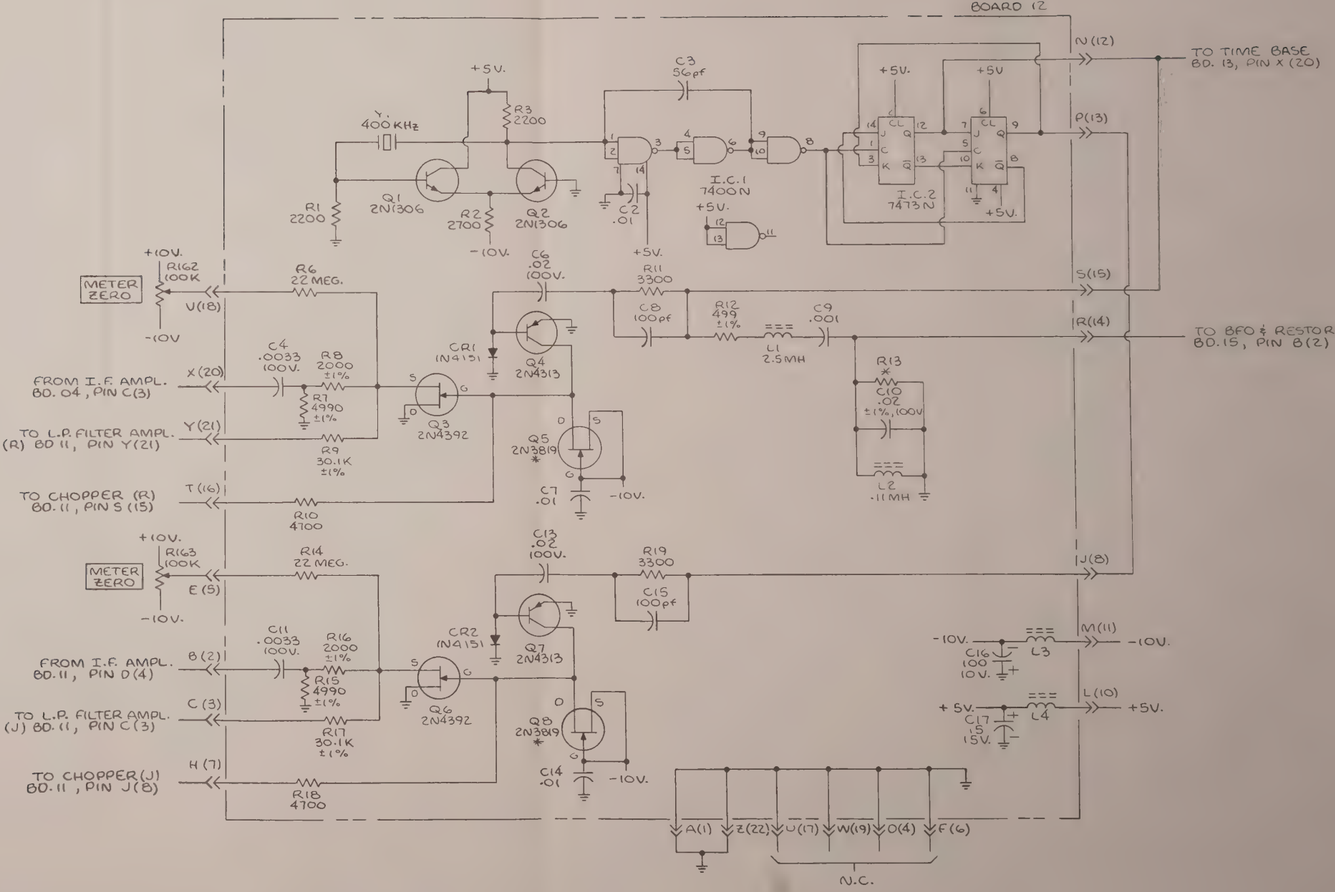
FIGURE 5-10. LP FILTER AMPLIFIER

TABLE 5-11. REPLACEABLE PARTS LIST

SYMBOL	PART NO.	DESCRIPTION
	8036	Board, P.C.
		Ejector, SAE No. 6100 (2 req'd.)
C1		(Not Used)
C2		Capacitor, 0.01 MFd, ±20%, 1000V, Erie Type 811
C3		Capacitor, 56 Pf, ±5%, 500V, Arco No. DM-15
C4		Capacitor, 0.0033 Mfd, ±5%, 600V, Arco MPD
C5		(Not Used)
C6		Capacitor, 0.02 Mfd, ±5%, 100V, Arco No. MPD
C7		Capacitor, 0.01 Mfd, ±20%, 1000V, Erie Type 811
C8		Capacitor, 100 Pf, ±10%, 1000V, Centralab No. DD-101
C9		Capacitor, 1000 Pf, ±1%, 100V, Arco No. DM-15
C10		Capacitor 0.02 Mfd, ±5%, 100V, Arco No. MPD
C11		Capacitor, 0.0033 Mfd, ±5%, 600V, Arco No. MPD
C12		(Not Used)
C13		Capacitor, 0.02 Mfd, ±5%, 100V, Arco No. MPD
C14		Capacitor, 0.01 Mfd, ±20%, 1000V, Erie Type 811
C15		Capacitor, 100 Pf, ±10%, 1000V, Centralab No. DD-101
C16		Capacitor, 100 Mfd, ±20%, 10V, Sprague Type 196D
C17		Capacitor, 15 Mfd, ±10%, 15V, Sprague Type 196D
CR1		Diode, 1N4151
CR2		Diode, 1N4151
IC1		Integrated Circuit 7400N
IC2		Integrated Circuit 7473N
L1	8058	Coil
L2	8125	Coil
L3	7387	Coil
L4	7387	Coil

SYMBOL	PART NO.	DESCRIPTION
Q1	5616-1	Transistor, (2N1306)
Q2	5616-1	Transistor, (2N1306)
Q3		FET, 2N4392
Q4	5647-1	Transistor, (2N4313)
Q5	5638-12-1	FET, (2N3819)
Q6		FET, 2N4392
Q7	5647-1	Transistor, (2N4313)
Q8	5638-12-1	FET, (2N3819)
R1		Resistor, 2200 Ohms, ±10%, 1/4W, A-B type CB
R2		Resistor, 2700 Ohms, ±10%, 1/4W, A-B type CB
R3		Resistor, 2200 Ohms, ±10%, 1/4W, A-B type CB
R4		(Not Used)
R5		(Not Used)
R6		Resistor, 22 Megohms, ±10%, 1/4W, A-B type CB
R7		Resistor, 4990 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R8		Resistor, 2000 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R9		Resistor, 30.1K Ohms, ±1%, 1/8W, IRC No. CEA-TO
R10		Resistor, 4700 Ohms, ±10%, 1/4W, A-B type CB
R11		Resistor, 3300 Ohms, ±10%, 1/4W, A-B type CB
R12		Resistor, 499 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R13		Resistor *(Factory Select)
R14		Resistor, 22 Megohms, ±10%, 1/4W, A-B type CB
R15		Resistor, 4990 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R16		Resistor, 2000 Ohms, ±1%, 1/8W, IRC No. CEA-TO
R17		Resistor, 30.1K Ohms, ±1%, 1/8W, IRC No. CEA-TO
R18		Resistor, 4700 Ohms, ±10%, 1/4W, A-B type CB
R19		Resistor, 3300 Ohms, ±10%, 1/4W, A-B type CB
Y1		Crystal, 400 KHz, Bliley BH64W





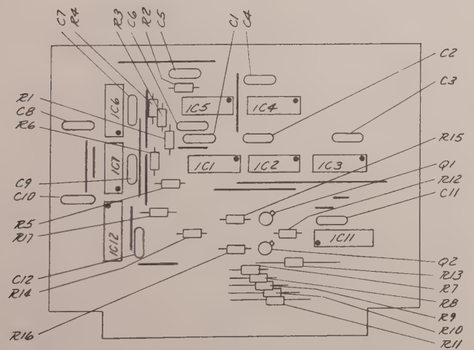
C-8432-A

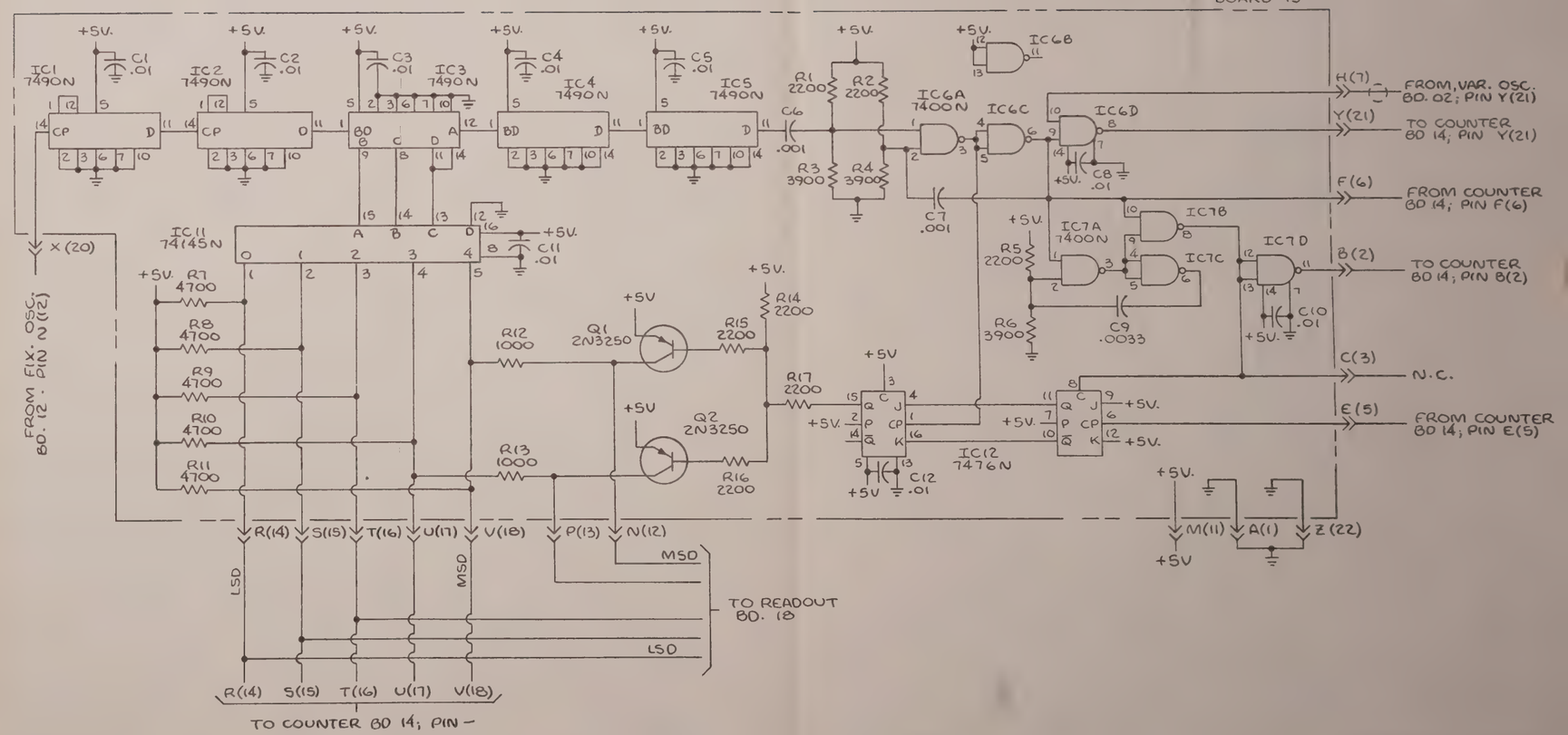
FIGURE 5-11. FIXED OSCILLATOR AND 2nd MODULATOR

TABLE 5-12. REPLACEABLE PARTS LIST

SYMBOL	PART NO.	DESCRIPTION
	8037	Board, P.C.
		Ejector, SAE No. 6100 (2 req'd.)
C1 Thru C5		Capacitor, 0.01 Mfd, ±20%, 1000V, Erie Type 811
C6, C7		Capacitor, 0.001 Mfd, ±20%, 1000V, Spraque No. 5GA
C8		Capacitor 0.01 Mfd, ±20%, 1000V, Erie Type 811
C9		Capacitor, 0.0033 Mfd, ±5%, 600 V, Arco MPD
C10 Thru C12		Capacitor 0.01 Mfd, ±20%, 1000V, Erie Type 811
IC1 Thru IC5		Integrated Circuit, 7490N
IC6 Thru IC7		Integrated Circuit, 7400N
IC8 Thru IC10		(Not Used)
IC11		Integrated Circuit, 74145N
IC12		Integrated Circuit, 7476N
Q1	5620-1	Transistor (2N3250)
Q2	5620-1	Transistor (2N3250)

SYMBOL	PART NO.	DESCRIPTION
R1		Resistor, 2200 Ohms, ±10%, 1/4W, A-B type CB
R2		Resistor, 220 Ohms, ±10%, 1/4W, A-B type CB
R3		Resistor, 3900 Ohms, ±10%, 1/4W, A-B type CB
R4		Resistor, 3900 Ohms, ±10%, 1/4W, A-B type CB
R5		Resistor, 220 Ohms, ±10%, 1/4W, A-B type CB
R6		Resistor, 3900 Ohms, ±10%, 1/4W, A-B type CB
R7 Thru R11		Resistor, 4700 Ohms, ±10%, 1/4W, A-B type CB
R12		Resistor, 1000 Ohms, ±10%, 1/4W, A-B type CB
R13		Resistor, 1000 Ohms, ±10%, 1/4W, A-B type CB
R14		Resistor, 220 Ohms, ±10%, 1/4W, A-B type CB
R15		Resistor, 2200 Ohms, ±10%, 1/4W, A-B type CB
R16		Resistor, 2200 Ohms, ±10%, 1/4W, A-B type CB
R17		Resistor, 2200 Ohms, ±10%, 1/4W, A-B type CB



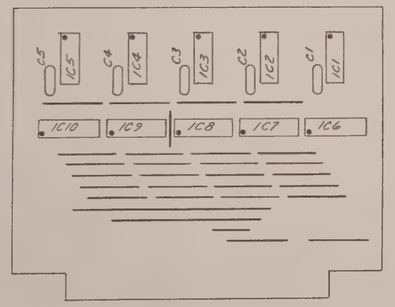


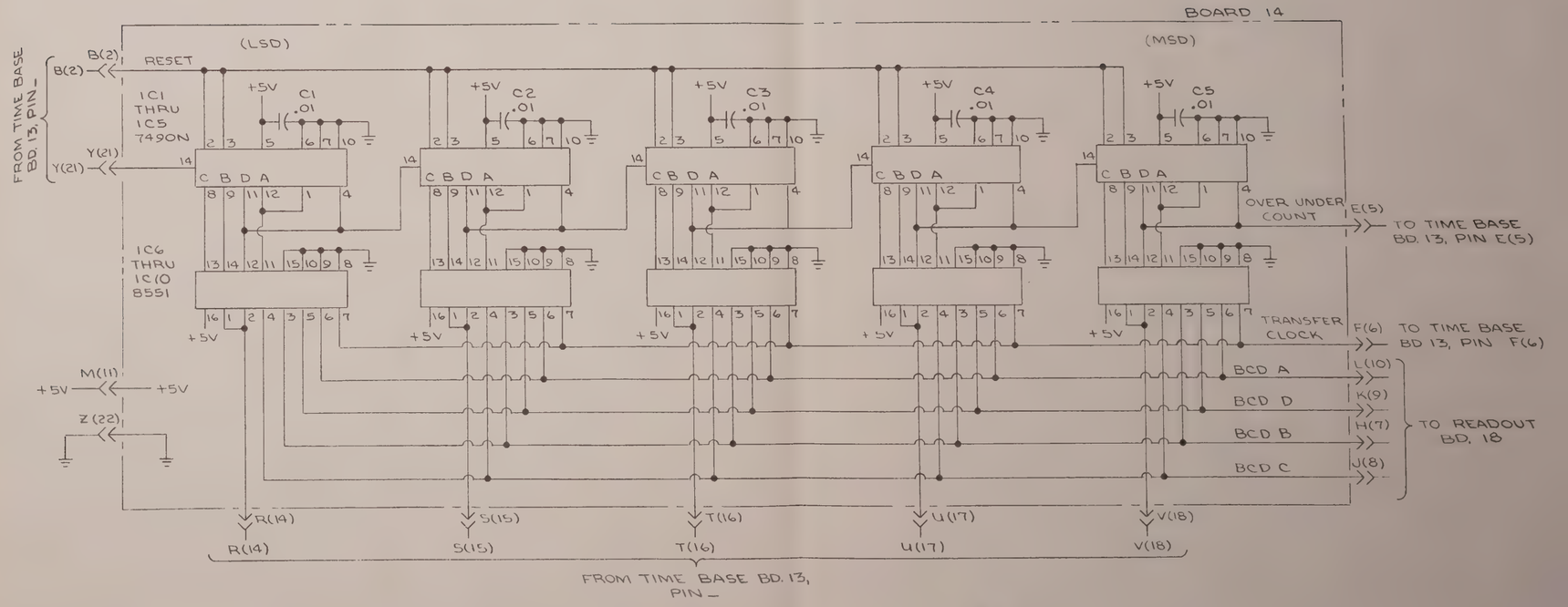
T-8433-A

FIGURE 5-12. TIME BASE

TABLE 5-13. REPLACEABLE PARTS LIST

SYMBOL	PART NO.	DESCRIPTION
	8038	Board, P.C.
		Ejector, SAE No. 6100 (2 req'd.)
C1 Thru C5		Capacitor, 0.01 Mfd, ±20%, 1000V, Erie Type 811
IC1 Thru IC5		Integrated Circuit, 7490N
IC6 Thru IC10		Integrated Circuit, 8551



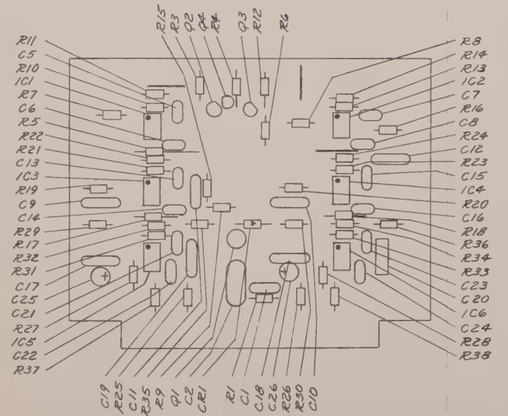


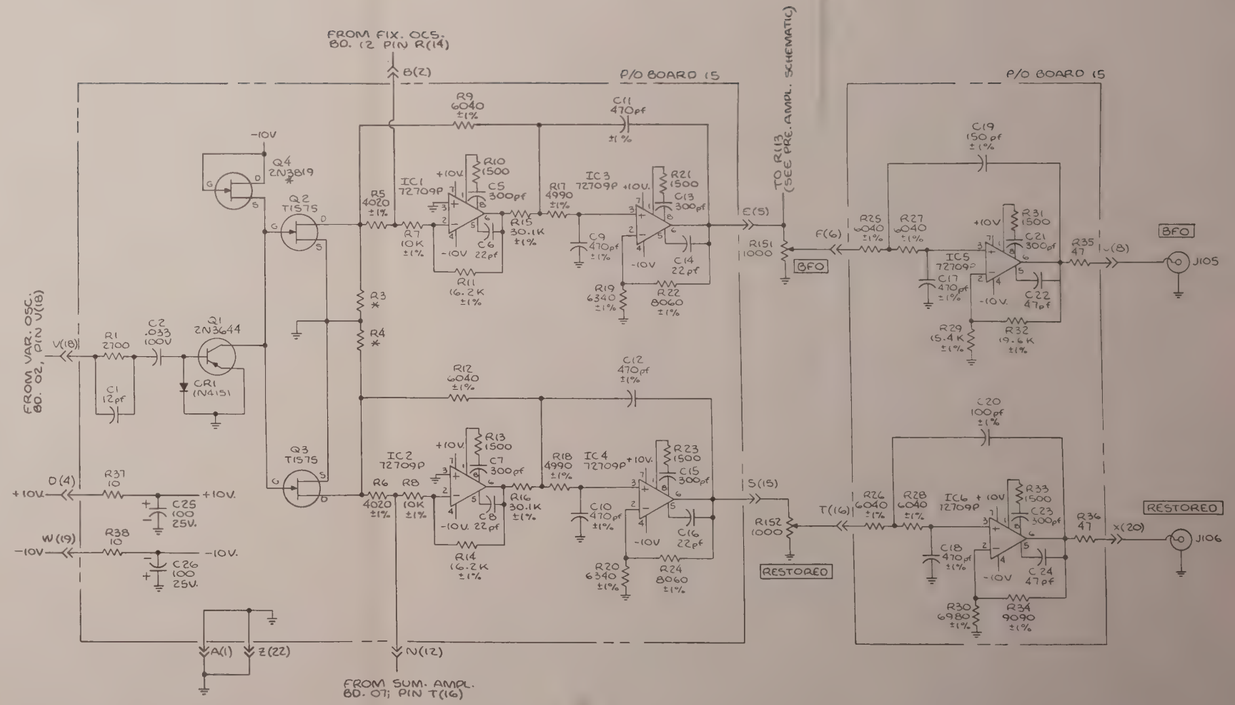
T-8434-A

FIGURE 5-13. COUNTER AND MULTIPLEXER

TABLE 5-14. REPLACEABLE PARTS LIST

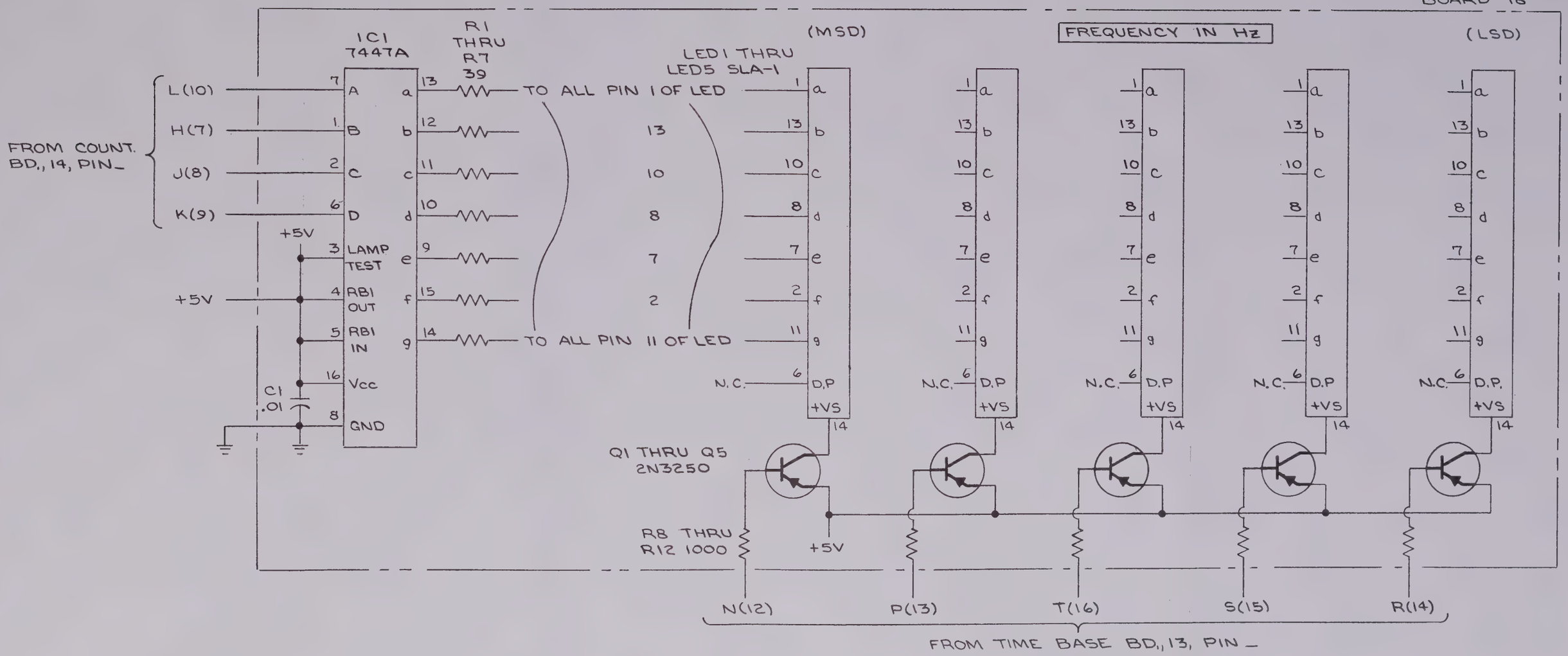
SYMBOL	PART NO.	DESCRIPTION
		Board, P.C.
		Ejector, SAE No. 6100 (2 req'd.)
C1		Capacitor, 12 Pf, ± 10%, 1000V, Centralab No. DD-120
C2		Capacitor, 0.033 mfd, ± 5%, 100V, Arco No. MPD
C3		(Not Used)
C4		(Not Used)
C5		Capacitor, 300 Pf, ± 10%, 1000V, Centralab No. DD-301
C6		Capacitor, 300 Pf, ± 10%, 1000V, Centralab No. DD-220
C7		Capacitor, 300 Pf, ± 10%, 1000V, Centralab No. DD-301
C8		Capacitor, 22 Pf, ± 10%, 1000V, Centralab No. DD-220
C9		Capacitor, 470 Pf, ± 1%, 300V, Arco No. DM-15
C10		Capacitor, 470 Pf, ± 1%, 300V, Arco No. DM-15
C11		Capacitor, 470 Pf, ± 1%, 300V, Arco No. DM-15
C12		Capacitor, 470 Pf, ± 1%, 300V, Arco No. DM-15
C13		Capacitor, 300 Pf, ± 10%, 1000V, Centralab No. DD-301
C14		Capacitor, 24 Pf, ± 10%, 1000V, Centralab No. DD-220
C15		Capacitor, 300 Pf, ± 10%, 1000V, Centralab No. DD-301
C16		Capacitor, 22 Pf, ± 10%, 1000V, Centralab No. DD-220
C17		Capacitor, 470 Pf, ± 1%, 300V, Arco No. DM-15
C18		Capacitor, 470 Pf, ± 1%, 300V, Arco No. DM-15
C19		Capacitor, 150 Pf, ± 1%, 300V, Arco No. DM-15
C20		Capacitor, 100 Pf, ± 1%, 300V, Arco No. DM-15
C21		Capacitor, 300 Pf, ± 10%, 1000V, Centralab No. DD-301
C22		Capacitor, 47 Pf, ± 10%, 1000V, Centralab No. DD-470
C23		Capacitor, 300 Pf, ± 10%, 1000V, Centralab No. DD-301
C24		Capacitor, 47 Pf, ± 10%, 1000V, Centralab No. DD-470
C25, C26		Capacitor, 100 mfd, ± 20%, 10V, Sprague Type No. 196D
CR1		Diode, 1N4151
IC1 Thru IC6	5650-1	Integrated Circuit, (72709P)
Q1	5626-1	Transistor, 2N3644
Q2		FET, T1S75
Q3		FET, T1S75
Q4	A-5639-10-1	Transistor, (2N3819)
R1		Resistor, 2700 Ohms, ± 10%, 1/4W, A-B type CB
R2		(Not Used)
R3		* (Factory Select)
R4		* (Factory Select)
R5		Resistor, 4020 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R6		Resistor, 4020 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R7		Resistor, 10K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R8		Resistor, 10K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R9		Resistor, 6040 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R10		Resistor, 1500 Ohms, ± 10%, 1/4W, A-B type CB
R11		Resistor, 16.2K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R12		Resistor, 6040 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R13		Resistor, 1500 Ohms, ± 10%, 1/4W, A-B type CB
R14		Resistor, 16.2K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R15		Resistor, 30.1K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R16		Resistor, 30.1K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R17		Resistor, 4990 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R18		Resistor, 4990 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R19		Resistor, 6340 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R20		Resistor, 6340 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R21		Resistor, 1500 Ohms, ± 10%, 1/4W, A-B type CB
R22		Resistor, 8060 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R23		Resistor, 1500 Ohms, ± 10%, 1/8W, IRC No. CEA-TO
R24		Resistor, 8060 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R25		Resistor, 6040 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R26		Resistor, 6040 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R27		Resistor, 6040 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R28		Resistor, 6040 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R29		Resistor, 15.4K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R30		Resistor, 6980 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R31		Resistor, 1500 Ohms, ± 10%, 1/4W, A-B type CB
R32		Resistor, 19.6K Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R33		Resistor, 1500 Ohms, ± 10%, 1/4W, A-B type CB
R34		Resistor, 9090 Ohms, ± 1%, 1/8W, IRC No. CEA-TO
R35		Resistor, 47 Ohms, ± 10%, 1/4W, A-B type CB
R36		Resistor, 47 Ohms, ± 10%, 1/4W, A-B type CB
R37		Resistor, 10 Ohms, ± 10%, 1/4W, A-B type CB
R38		Resistor, 10 Ohms, ± 10%, 1/4W, A-B type CB





C-8435-A

FIGURE 5-14. BFO AND RESTORED



T-8436-A

FIGURE 5-15. READOUT

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